POWER

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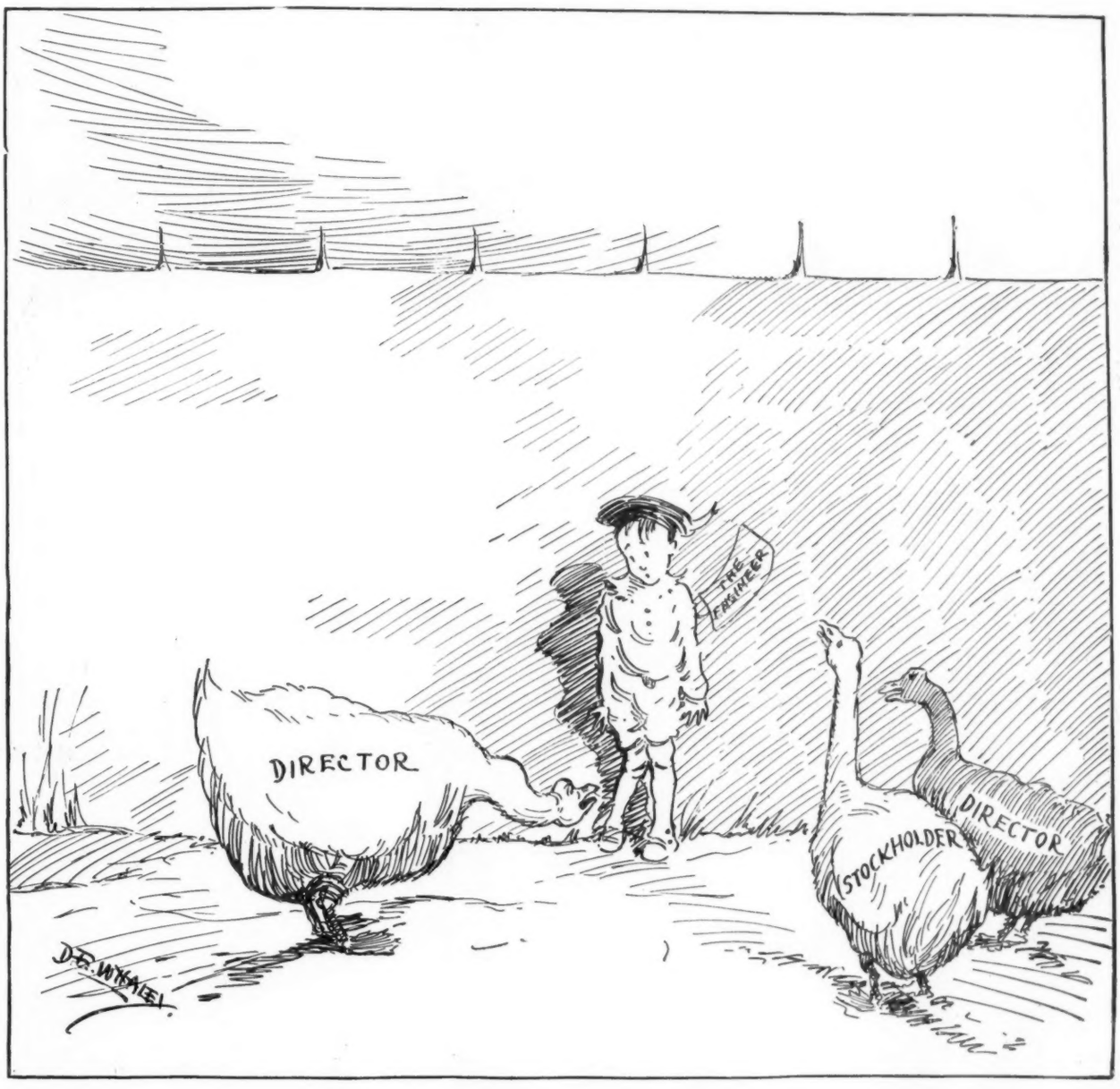
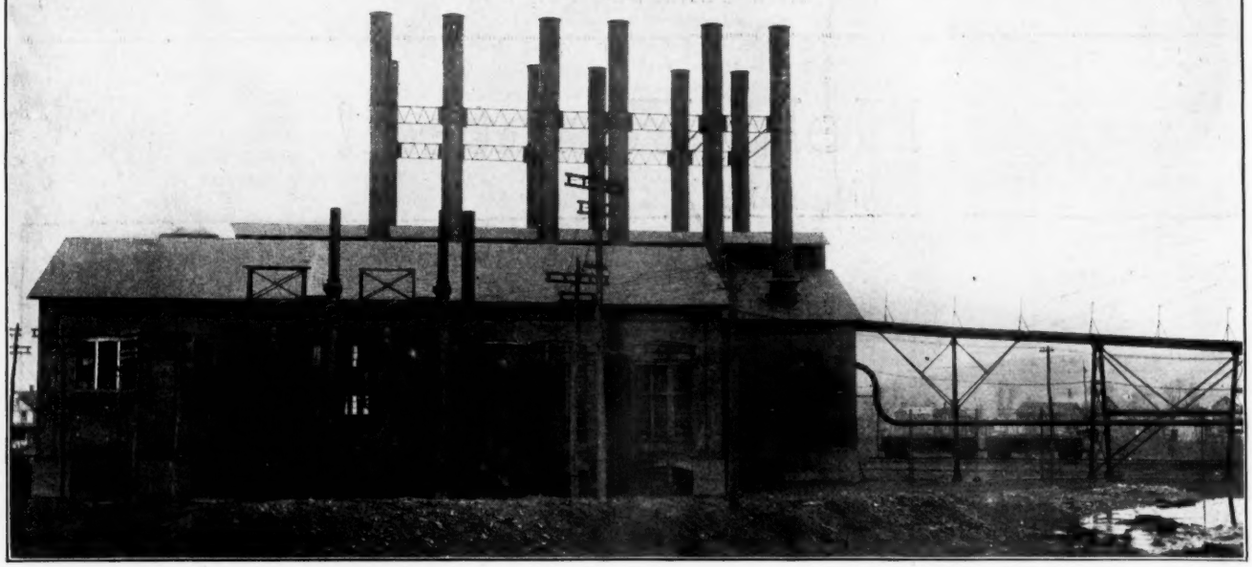
Help Wanted!



If you have ever been hectored by a Board of Directors you can sympathize

Lucerne Mines Power Plant

By Warren O. Rogers



SYNOPSIS—A 12,000-kw. capacity steam-turbine power plant supplying electrical energy to a group of mines. Bone fuel, with a heating value of between 8,500 and 12,000 B.t.u. and containing from 20 to 35 per cent. ash, is burned in the boiler furnaces and is fired by underfeed stokers. The condenser for the larger, 6,000-kw., turbine is connected to the exhaust line by a 66-in. corrugated electrically lap-welded single-piece 3/8-in. thick connecting pipe.

When a coal-mine power plant is mentioned, one generally thinks of high-speed reciprocating engines, either belted or directly connected to the generators. The Lucerne power station of the Rochester & Pittsburgh Coal Co., at the Lucerne mines, Lucerne, Penn., on the contrary is of uptodate design and has some interesting features.

The 12,000-kw. station was erected in 1914 on the Buffalo, Rochester & Pittsburgh R.R., about 4 mi. from Indiana, Penn. It was built at this site because of the desirability of erecting a tipple for handling the coal from one shaft and two drifts which reach the Freeport seam of bituminous coal. The water supply for condensers and boilers is abundant, and the handling of fuel is simplified by having the power plant close to the tipple, the bone and refuse from which are used as fuel in the boiler room. The capacity of the tipple is from 6,000 to 10,000 ton per 10 hours, according to the cleaning condition of the coal. The screen separates lump and nut and slack grades of coal. The refuse that is picked from the coal is delivered through chutes at the side of the men to a conveyor that carries it to a refuse picking table. Here the bone, after having the slate picked from it, passes to a set of crushing rolls where it is reduced and then passes to a storage bin in front of the tipple. From this bin the fuel is conveyed by an electrically operated 5-ton larry to the 475-ton capacity bunker in the boiler room. The larry track is shown at the right of the leading illustration showing an exterior view of the power plant.

Steam for the generating units and for the hoisting engine and tipple machinery and two large mine pumps is supplied by twelve 500-hp. water-tube boilers, at 165 lb. pressure. They are placed in two rows and in six batteries of two boilers each (top view, Fig. 1). Each boiler furnace is fed by three underfeed stokers. The fuel is fed to the stoker hoppers through chutes that connect to the bottom of the fuel bunker.

The bone fuel used in the furnaces varies in heating value from 8,500 to 12,000 B.t.u. and contains from 20 to 35 per cent. of ash. The average water evaporated per pound of fuel is about 7½ lb., and 3¼ lb. of fuel as it comes to the stokers is burned per kilowatt output of the generators. As there is no market for this bone fuel and as its disposal, if not consumed in the furnaces, would be charged to the cost of marketing the prepared coal, its use in the boiler room greatly reduces the volume of this refuse to be removed and at the same time furnishes fuel to the power plant at a very low cost. About 150 tons of bone fuel are burned each 24 hr. The economy of the new plant as compared with operating several smaller ones is evident from the fact that one of them, now discarded, formerly used for driving air compressors for mine use and running noncondensing, burned on an average 150 tons of marketable coal each 24 hr., which at, say, a market value of $1.10 per ton means a saving in the fuel cost of $165 per day of 24 hr.

The ashes from the furnace ashpits are wet down and loaded directly into empty coal cars that are run into position for receiving them. Fig. 2 shows a car being run into place ready for loading. As the track is on a grade,

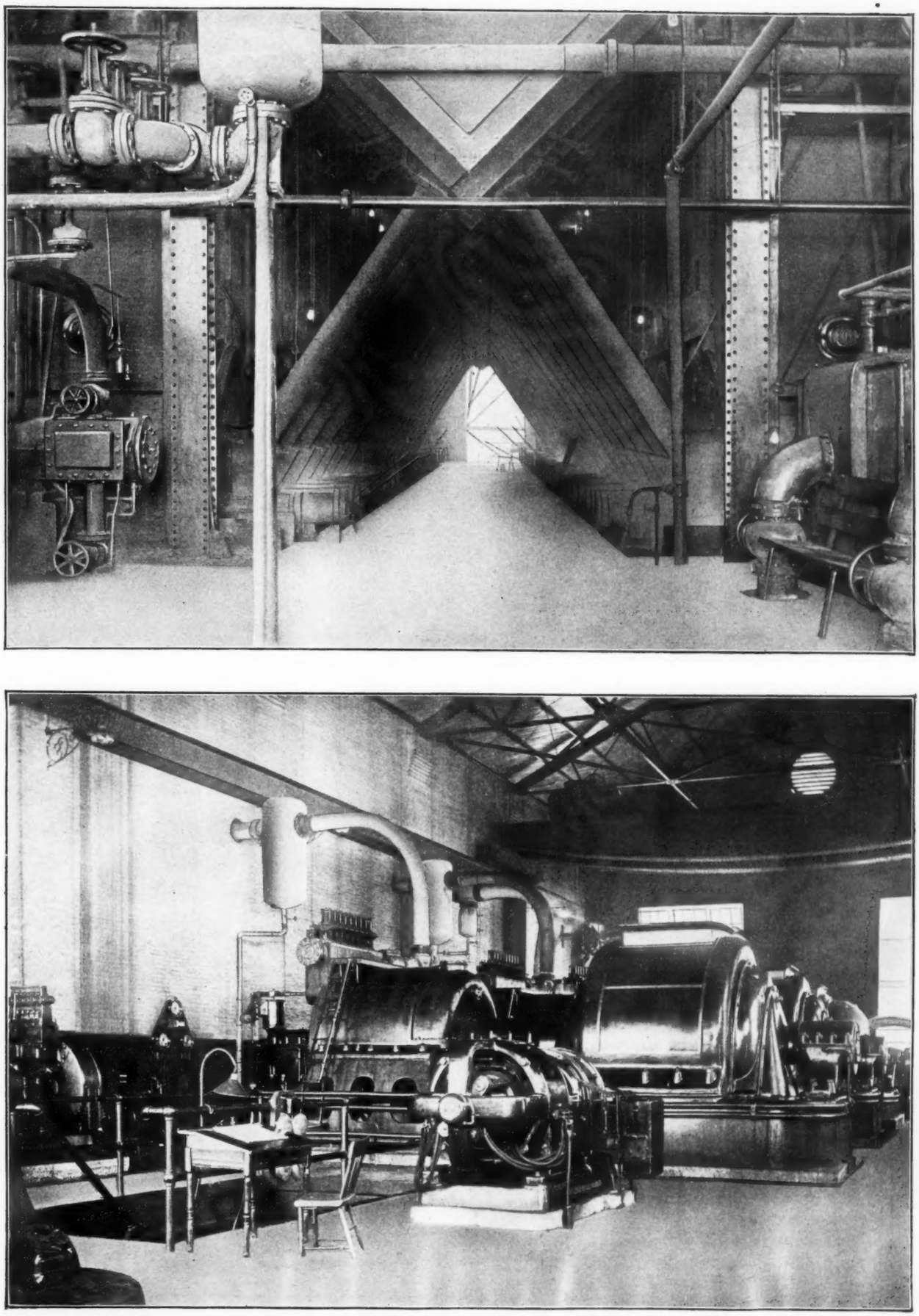


FIG. 1. BOILER AND ENGINE ROOMS OF THE LUCERNE MINES POWER PLANT

the empty cars run by gravity to the loading points. When loaded, they are hauled away by a locomotive.

To burn the bone fuel successfully, forced draft is necessary. It is supplied by two 11-ft. diameter 5-ft. 3-in. wide semi-inclosed fans each driven by a 13x16-in. horizontal engine at a maximum speed of 225 r.p.m.

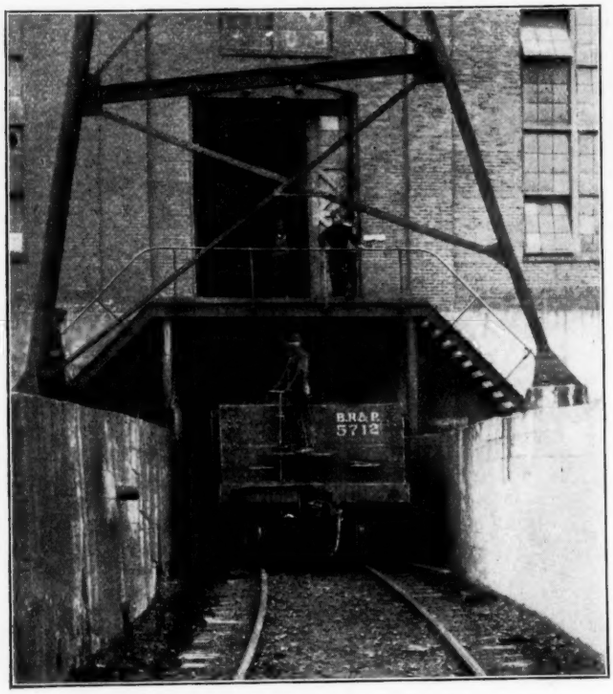


FIG. 2. EMPTY CAR GOING INTO ASHPIT

An air pressure of from 2 to 2½ in. of water is maintained and it requires careful manipulation to get from 10 to 14 per cent. CO_2.

Boiler feed and condensing water is obtained from a local stream, Yellow Creek, where the pumphouse is located, about 800 ft. from the plant. Water is handled by two 14-in. motor-driven pumps each of 5,000-gal. per min. capacity. There are also one 14-in. 10,000-gal. and one 16-in. 7,000-gal. capacity centrifugal pump. These pumps work against a head of from 50 to 65 ft. and all discharge into a main header at the power house, from which branches are taken to the condensers, heater purifiers and to two storage tanks, with a total capacity of 50,000 gal. A supply line is also run to four town-supply tanks on a hill about one-half mile distant, having a total capacity of 100,000 gal.

Boiler-feed water is heated to 204 deg. and is slightly treated in two 3,000-hp. capacity feed-water heaters and purifiers. Exhaust steam is used from the auxiliary units about the plant. These heaters, and also the forced-draft equipment, are installed at one end of the boiler room, as partly shown in Fig. 1.

In the turbine room are two 3,000-kw. 5-stage turbo-generators delivering 6,600-volt three-phase 25-cycle current at 1,500 r.p.m. and one 6,000-kw. unit delivering current at the same voltage and frequency.

The advancement in turbine design is well illustrated in these turbines (lower view of Fig. 1 and in Fig. 3). The new 6,000-kw. unit, having a capacity equal to the other two machines, occupies practically the same floor space, and when running with a 5,000-kw. load, will save the steam that can be generated by one

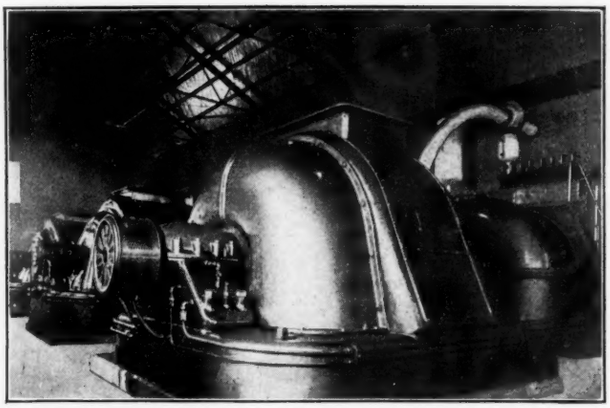


FIG. 3. THE 6,000-KW. TURBO-GENERATOR

of the 500-hp. boilers over what would be consumed if the same load were being carried by the two smaller turbines. Saturated steam is used throughout the plant.

Excitation is furnished by a 65-kw. 125-volt direct-current motor-generator set and a 100-kw. 125-volt turbine-driven direct-current generator set. These exciter units are at the center and left of turbine room, Fig. 1.

The two 3,000-kw. turbines exhaust to barometric ejector condensers, each being connected to a 12&30x18-in. steam-driven air pump. The 6,000-kw. unit exhausts into a barometric condenser, the exhaust-steam pipe of which is 66 in. diameter (Fig. 4). This pipe is electrically lap-welded and extends from the steam line to the condenser. It is slightly corrugated to provide additional stiffness for the vacuum service. It is made of ⅜-in. steel, with the corrugations on 8-in. centers and about ½ in. deep. At each end are attached seamless forged

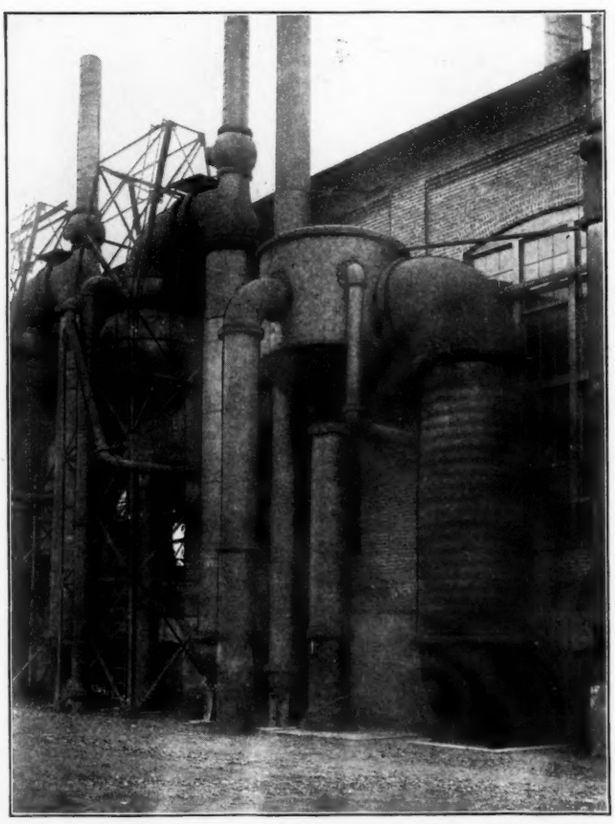


FIG. 4. BAROMETRIC CONDENSER WITH 66-IN. CORRUGATED EXHAUST STEAM PIPE

steel flanges. So far as known this application of large-diameter corrugated lap-welded piping for vacuum service is new.

The cross-compound air compressor exhausts into a fourth barometric condenser, that is connected to a 7x16x14-in. air pump. The steam cylinders are 20x30 in.; air 20¼x30 in. on the high-pressure side, steam 38x30 in.; air 33¼x30 in. on the low-pressure side. The air pressure is carried at about 85 lb. and is used for operating air drills, etc., in the mines; it is about to be disposed of.

The turbine room contains a 50-ton crane of 50-ft. span that can be operated electrically or by hand.

Steam from the boilers is metered by a steam-flow meter.

When the plant was first designed, the power requirements for the existing mines and others to be operated were such as to warrant erecting a central station. This was largely owing to the abandonment of air in favor of electric-driven pumps, chain machines, rock drills and the adoption of electric-locomotive haulage in the mines. The station will eventually supply energy to about 25 mines at a distance of from 8 to 15 mi. The current is sent at 6,600 volts to nine substations situated at convenient points, where it is transformed for use in the mines. A portable substation is also at hand for use if one of the permanent stations becomes disabled.

The plant was designed and erected under the direction of L. W. Robinson, president of the company, by Hiel Patterson, engineer, and was put in operation in March, 1911. The 6,000-kw. unit is an addition of 1915. F. M. Fritchman is general manager, L. W. Householder, electrical engineer and the plant is operated under the supervision of John Couser, chief engineer.

PRINCIPAL EQUIPMENT OF THE LUCERNE MINES POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
12	Boilers	Stirling	500-hp	Steam generators	Forced-draft, stoker-fed, 165 lb. steam	Babcock & Wilcox Co.
36	Stokers	Jones		Boiler furnaces	Automatic	Underfeed Stoker Company of America
2	Fans	Semi-housed	11 ft. dia., 5 ft., 3 in. wide	Forced draft	225 r.p.m., 2 to 2½ in. air pressure	Clarage Foundry & Mfg. Co.
2	Engines	Horizontal	13x16-in.	Driving forced-draft fans	225 r.p.m., 165 lb. steam	Ball Engine Co.
2	Pumps	Centrifugal	14-in.	Water to power plant	Motor-driven, 7,000 gal. per min.	De Laval Steam Turbine Co.
1	Pump	Centrifugal	16-in.	Water to power plant	Motor-driven, 7,000 gal. per min.	De Laval Steam Turbine Co.
1	Pump	Centrifugal	24-in.	Water to power plant	Motor-driven, 10,000 gal. per min.	Alberger Pump & Condenser Co.
2	Heaters	Cochrane	3,000-gal.	Heating and purifying feed water	Exhaust steam	Harrison Safety Boiler Works
2	Turbines	Five-stage	3,000-kw.	Main gen. units	1,500 r.p.m., 6,600 volts, 3-phase, 25 cycles, 165 lb. steam	General Electric Co.
1	Turbine	Eight-stage	6,000-kw.	Main gen. unit	1,500 r.p.m., 6,600 volts, 3-phase, 25 cycles, 165 lb. steam	General Electric Co.
1	Generator	Direct-current	65-kw.	Exciter set	735 r.p.m. motor-driven	General Electric Co.
1	Generator	Direct-current	100-kw.	Exciter set	Turbine-driven	General Electric Co.
1	Generator	Direct-current	100-kw.	Exciter set	1,500 r.p.m., directly connected to turbine shaft	General Electric Co.
1	Turbine	Curtis	100-kw.	Driving exciter	165 lb. steam, saturated	General Electric Co.
1	Motor	Alt.-current	100-hp	Driving exciter	735 r.p.m., 3-phase, 25 cycles	General Electric Co.
2	Condensers	Barometric		With 3,000-kw. turbines		Wheeler Condenser & Engineering Co.
1	Condenser	Barometric		With 6,000-kw. turbine		Alberger Pump & Condenser Co.
2	Pumps	Dry-air	12x30x18-in.	With 3,000-kw. condensers	Steam-driven	Wheeler Condenser & Engineering Co.
1	Pump	Dry-air	12x30x24-in.	With 6,000-kw. condenser	Steam-driven	Alberger Pump & Condenser Co.
1	Motor	Synchronous	710-hp	Motor-gen. set	750 r.p.m., 6,600 volts, 3-phase, 25 cycles	General Electric Co.
1	Generator	Direct-current	500-kw.	Motor-gen. set	750 r.p.m., 575 volts	General Electric Co.
1	Compressor	Cross-compound	Steam, 20x38x30-in. Air 20¼x33¼x30-in.	Compressing air	Steam-driven, 85 lb. pressure	Ingersoll-Rand Co.
1	Condenser	Barometric		With air compressor		Wheeler Condenser & Engineering Co.
1	Pump	Dry-air	7x16x14-in.	With air-compressor condenser	Steam-driven	Wheeler Condenser & Engineering Co.
1	Crane	Motor-operated	50-ton	Turbine room	Motor- and hand-operated	Whiting Foundry Equipment Co.
1	Meter	Steam-flow		Metering feed water		General Electric Co.

Furnace and Boiler Losses

By R. Cederblom

SYNOPSIS—What progress if any has been made in regard to steam generation in 40 years? Is it not true that the results in most steam plants are not much in advance of what could be obtained in the days of James Watt? And is not the reason because both furnaces and boilers have been fairly efficient apparatus from the very beginning? These questions are discussed in this article.

Progress in the construction of boilers and furnaces to meet the constant demand for higher steam pressure and greater capacity per unit of floor space has been made, and there are better facilities for handling large amounts of coal, stokers, etc., but the adoption of modern machinery has not been followed by any marked improvements in economy except in reduced labor cost, the efficiency of furnaces and boilers depending largely on the way in which they are operated.

The fact that generally poor results are produced irrespective of the kind of equipment in the respective plants shows that the equipment is not handled properly.

The boiler manufacturer and furnace builder will guarantee a certain combined boiler and furnace efficiency something like 72 per cent. under favorable conditions, their own experts conducting the test. But as soon as the plant is turned over to the owner and his operators, this efficiency will almost invariably toboggan until it finally

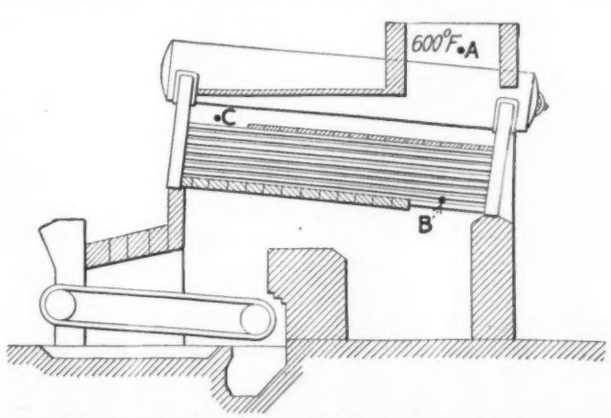


FIG. 1. A COMMON TYPE OF BOILER SETTING

reaches a point far below that guaranteed by the builders. This holds true irrespective of the type of boiler and furnace installed, showing that with all modern apparatus economy is largely dependent on the skill of the operator.

The case of the owner of a certain fair-sized plant illustrates the condition existing in the power-plant field. He believed that he was short of boiler capacity and placed an order for a new unit of a different type from what was already in the plant, just because the manufacturer had guaranteed an increase of 15 per cent. in efficiency with this particular boiler. As a matter of fact the efficiencies of the old boilers were not known, as no evaporation tests had ever been made, and with no attempt at measuring the steam used for different purposes, the cost per thousand pounds of steam in this plant was unknown. From the general appearance of conditions there is no doubt that a better system of handling the equipment already on hand would have made the additional boiler unnecessary.

A certain plant has two 400-hp. water-tube boilers with chain-grate stokers. One boiler will generate sufficient steam for the plant ten hours per day if run at about 125 per cent. rating, the rest of the time running with a light load and part of the night it has banked fires—not ideal conditions for obtaining the highest efficiency. The firemen follow out the instructions of the engineer in charge, who is a man awake to modern ideas. The plant is equipped with damper regulators, and a gas-analyzing instrument is furnished by the owner, who coöperates with the engineer in every way and keeps tab on the daily performances. Gas samples are taken regularly, and a close watch is kept on furnace conditions.

This plant produces 1,000 lb. of steam at a cost for fuel of from 15 to 16c. from coal that costs $2.20 per ton delivered in the bunkers and analyzes on an average 10,500 B.t.u. as fired. They are able to maintain a 24-hr. efficiency at from 67 to 70 per cent. by intelligent handling of equipment not in any respect different or superior to what is found in thousands of other plants. This performance, however, although above what is found in most steam plants, is, even with modern apparatus, not any better than could have been obtained fifty years ago with any old style of common grate and fire-tube boiler and a skillful fireman handling the scoop.

A large concern operates several good-sized plants that burn as high as 50,000 tons of coal per year. An elaborate bookkeeping system is in use, and petty expenses are down to a minimum, and the same policy is carried out in regard to the wages paid their engineers and firemen. Although the cost of manufactured production is down to scientific perfection, but little attention is paid to the cost of the steam generated. The engineers are kept busy outside the boiler rooms and probably would not know how to get efficiency anyhow. The master mechanic for the concern has a "test" made once in a while, and if the evaporation does not come up to expectation, the fault is laid to adverse running conditions and let go at that. A general increase of at least two pounds of evaporation per pound of coal could probably be effected in the plants of this concern, which would mean at least $25,000 saved every year—many times what it would cost to equip the different plants with necessary instruments and pay the salary of a competent combustion engineer to look after their operation.

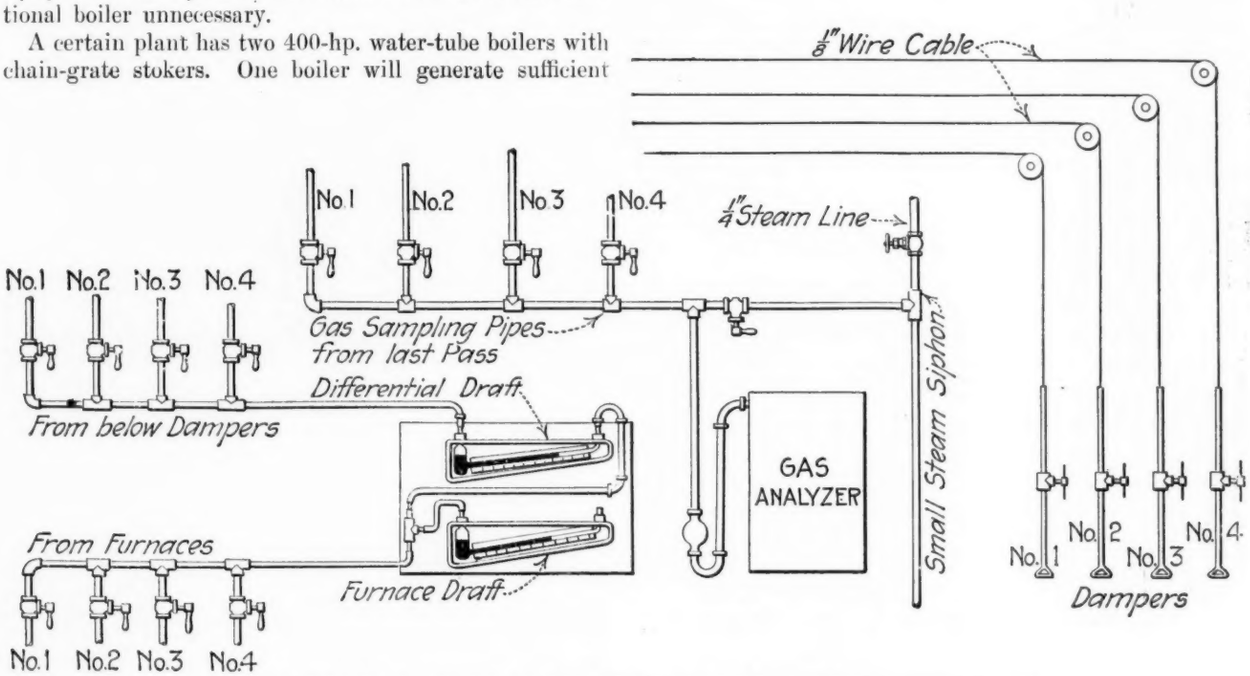


FIG. 2. GENERAL DESIGN OF BOILER-ROOM FOREMAN'S OPERATING BOARD

The adoption of instruments such as the gas analyzer, for instance, is a help in getting results. By the use of such appliances it is possible to determine what actually takes place in the furnace and combustion chamber, which helps to better regulate the fires and the air supply to meet the different conditions. The results, however, depend as much on the operator as ever. The adoption of these instruments has not led to any improvement in steam-generating apparatus, and to get reasonable efficiency from present boilers and furnaces means the performing of the same disagreeable and dirty work as fifty years ago. The heating surfaces become covered with soot and scale the same as ever; brick walls crack and leak, and firebrick linings and arches burn out and fall down faster than ever before, and to keep up a certain efficiency means everlasting attention, cleaning and repairing.

When going after efficiency in any boiler plant, it is well to keep in mind that the furnace and boiler are two different apparatus, performing distinctly different duties, the function of the furnace being to liberate the heat stored up in the fuel and that of the boiler to absorb as much of this heat as practicable. Therefore it may often be that an over-all low efficiency is the fault of only one of the two. If the furnace gives ideal combustion with the least practicable amount of excess air and the evaporation per pound of combustible shows up unreasonably low, then the boiler or baffling is to blame and requires attention.

On the other hand, the boiler may be in first-class condition and still the proper amount of steam is not generated per pound of coal burned, because the heat may be applied at such a low temperature that only a small percentage can be absorbed, and consequently it is a furnace problem. When judging the performance of the boiler and furnace separately, the true boiler efficiency should be considered and not the over-all efficiency as ordinarily figured. This means that the boiler should not be blamed for failing to absorb heat delivered to it which is not available for absorption.

With the instruments mentioned it becomes comparatively easy to locate and overcome wasteful methods and conditions as found in most of our boiler rooms, the gas analyzer being especially useful if intelligently applied.

Type of Boiler Setting

The type of boiler setting shown in Fig. 1 can be found almost anywhere, and it is desirable to get an idea of what the outfit is doing without going to the trouble of making an elaborate test. Place a thermometer in the uptake at *A* to find how much heat is being lost up the stack. Suppose the instrument shows 600 deg. F. There is a white-hot fire in the furnace, and the reading seems to justify the opinion from the looks of things that the boiler is doing splendid work, say 73 per cent. But is it really doing as well as that? To make sure, take a sample of flue gas and it shows 5 per cent. CO_2, for instance. How does that temperature of 600 deg. look now? If all that excess air rushed in through leaks in the upper part of the setting, it means that an amount of heat sufficient to heat all this cold air to 600 deg. has slipped by the heating surfaces of the boiler, consequently the temperature reading is misleading.

Should this 5-per cent. CO_2 represent conditions in the combustion chamber, it means that there is being used $\frac{20.7 - 5}{5} \times 100 = 314$ per cent. of excess air to burn the coal, with a corresponding loss of 23 per cent. in fuel, and it would also mean a furnace temperature of only about 1,000 deg. F. if the coal runs 12,000 B.t.u. From the gas analysis 314 per cent. excess air means that in addition to the 11.56 lb. of air necessary to burn the coal, there is $11.56 \times 3.14 = 36.3$ lb. of excess air, and the total weight of the gases from combustion per pound of coal will then be $1 + 11.56 + 36.3 = 48.86$ lb. Assuming the specific heat of the gases to be 0.24 and the coal analysis to show 12,000 B.t.u., the temperature of the gases in the combustion chamber will be $12{,}000 \div (48.86 \times 0.24) = 1{,}023$ deg. F.

Another sample of the gas taken through a stay-bolt just over the combustion chamber shows 9 per cent. CO_2. This brings the amount of excess air down to 130 per cent. with a corresponding increase of furnace temperature up to 1,818 deg. and cuts the preventable fuel loss from excess air to 7 per cent. The difference in the two gas samples shows that there must be a tremendous air leak somewhere between the two points where the samples were taken. To locate this leak, take another sample at a point halfway between where the first two were secured or through one of the upper stay-bolts in front, and this sample shows 8 per cent. CO_2. From *B* to *C* the excess air has increased from 130 to 159 per cent., probably from cracks in the brick walls and around the water legs, and perhaps the stay-bolt holes are not properly plugged. From *C* to *A*, however, is where the greatest leaks must be looked for. The CO_2 readings show that the air leakage is at the rate of $314 - 159 = 155$ cu.ft. of air to every 100 cu.ft. already contained in the mixture of gas and free air passing through the tube space at *C*. This air is at a temperature of 600 deg. F. by the time it reaches the uptake.

These approximate figures show that instead of an efficient combination of boiler and furnace, there is being wasted $530 \times 48.86 \times 0.24 = 6{,}215$ B.t.u. up the chimney out of every 12,000 B.t.u. fed into the coal hopper, or a combined efficiency of only about 48 per cent. The greatest loss is between the points *B* and *C*, which would indicate that the heating surface is either packed with soot and cinders on the outside or badly scaled on the inside, as the heat is not absorbed. There may be large openings in the baffles, allowing the gases to take a short cut for the last pass to the uptake.

Defective settings and bafflings with excessive leakage through them, together with poor judgment in regard to regulating air supply, are responsible for much of the poor economy shown in the average plant.

Most large plants employ water tenders, each fireman having too many fires to handle to give any attention to feed pumps or water levels. With a proper system of operation it would pay, even in small plants running only a few boilers, to have a trained water tender or boiler-room foreman. He should understand something about combustion and should be able to take gas samples and judge conditions of fires. Fig. 2 suggests a system of draft control and gas sampling by having the small siphon working at the end of the line. A sample from any one of the uptakes is brought up to the gas analyzer the moment the proper cock is opened, and a sample could be analyzed as quickly as if the instrument was applied directly to the individual setting. Control can thus be had of the performance of a number of furnaces, and if in addition a flow meter is provided for each individual boiler, the control will be ideal.

Changing the Speed of an Engine requires care in adjusting the governor springs so that the sounds, when they are tapped with a hammer, will be as nearly alike as it is possible to get them. If the sounds are different it is a case of unequal tension, resulting in unequal strain and may cause racing.

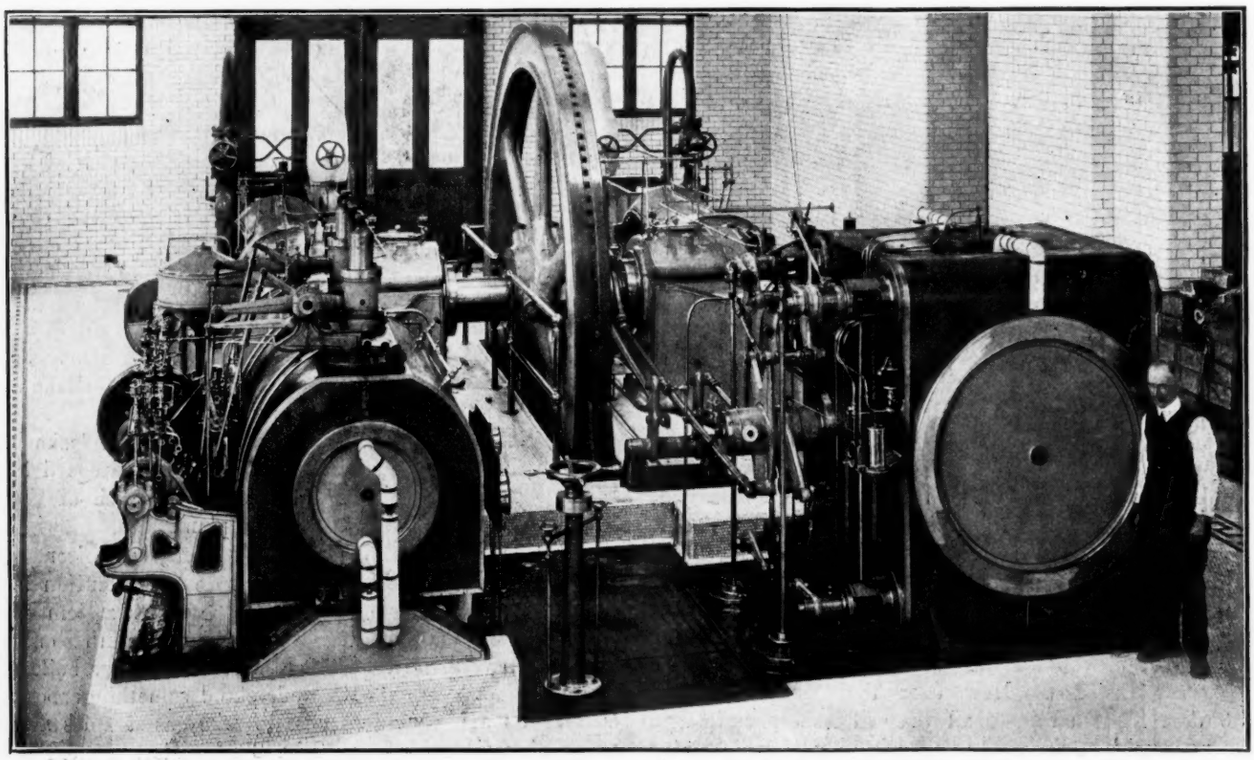
Internal Pressure Tests sustained by the various sizes of pipes should be not less than shown in the following table (National Tube Co.):

⅛- to 2-in. (inc.) butt-weld	700 lb.
2½- and 3-in. butt-weld	800 lb.
Up to 8-in. lap-weld	1,000 lb.
9- and 10-in. lap-weld	900 lb.
11- and 12-in. lap-weld	800 lb.
13- and 14-in. lap-weld	700 lb.
15-in. lap-weld	600 lb.

High-Efficiency Steam Ends for Ammonia Compressors

In recent installations of ammonia compressors, the question of steam economy has been given primary consideration. The use of high steam pressure and superheat is becoming common practice, calling for valves of the poppet type and refinement in cylinder and valve design to prevent distortion due to strains set up by the high temperatures. This applies to the high-pressure cylinder. The low-pressure cylinders are of the Corliss type since the entering steam is at moderate pressures and temperatures.

The poppet high, Corliss low, steam end of an ammonia compressor recently installed at the Old Colony Breweries, Fall River, Mass., illustrated in the accompanying photograph, is one of the most economical installations of this kind on record. The compressor was built by the De La Vergne Machine Co., New York, and the steam cylinders were built by the Nordberg Manufacturing Co., Milwaukee, Wis., and conform in general to the designs for combined poppet-Corliss compound engines which have been used recently for driving a constant-load electrolytic generator at the United States Metals Refining Co., Grasselli, Ind., for driving a paper mill at the John Lang Paper Co., Philadelphia, Penn., and for many other ammonia compressors, including machines at the American Ice Co., Philadelphia, American Ice Co., Boston, and the Savannah Brewing Co.



AMMONIA COMPRESSOR IN PLANT OF THE OLD COLONY BREWERIES, FALL RIVER, MASS.

Where the load is constant, or as in ammonia compressors, the mean effective pressure is constant, a compound engine can be designed for a single set of conditions and the highest economy can thereby be attained.

Referring to the photograph, the high-pressure cylinder is fitted with releasing-type poppet-valve gear with spring dashpots which are used for low- and moderate-speed machinery (40 to 100 r.p.m.) in order to insure sharp cutoff. The engine shown operates at a normal speed of 55 r.p.m. The valves are of the double-beat balanced type, seating in separate removable cages, which are ground tight into the cylinders. Both the high- and low-pressure cylinders are steam-jacketed, the piping to the heads being shown. Between the high- and low-pressure cylinders is a reheating receiver which dries and slightly superheats the steam passing to the low-pressure cylinder. The latter cylinder is fitted with Corliss valve gear with separate eccentrics for the steam and exhaust valves. The valves are of the multi-port type and are designed to present minimum valve-clearance volume and surface in contact with the steam during the inlet and expansion periods, so that the low-pressure cylinder has a high thermodynamic efficiency.

Low Steam Consumption of Engine

The steam end in this installation was guaranteed to operate with not to exceed 10.75 lb. of steam per i.hp.-hr. at normal load of 420 i.hp. with a pressure of 175 lb., 150 deg. superheat at the throttle and a vacuum of 26 in.

A test was run on May 10, 1915, in which precautions were taken to secure accurate readings of temperatures, pressures, vacuums and amount of condensate. Indicator cards were taken every fifteen minutes. The condensate was measured by calibrated barrels, and the correction for condenser leakage was determined by a separate preliminary test. The observations show a steam consumption of 9.91 lb. per i.hp. under conditions of 174 lb. pressure, 175 deg. superheat and 26¼ in. vacuum. The summary of the test is given in the following table:

TEST READINGS, MAY 10, 1915, OLD COLONY BREWERIES, FALL RIVER, MASS.

Test made by Louis Block, representing the Old Colony Breweries Co., and Mr. Green, representing the De La Vergne Machine Co.

Average steam pressure, lb.	174
Average steam temperature, deg. F.	552.41
Average superheat, deg. F.	175.41
Average vacuum at machines, in.	26¼
Revolutions per minute	55.85
Average indicated horsepower	411.5
Total water per hour, lb.	4,286.5
Condenser leakage per hour, lb.	211½
Net water per hour, lb.	4,075
Steam consumption, lb. per i.hp.-hr.	9.914

It is of interest to calculate the efficiency referred to the Rankine cycle. The heat per pound of steam corresponding to the initial conditions is 1,293.2 B.t.u. and to the exhaust conditions after adiabatic (or isentropic) expansion, 957 B.t.u., making the heat theoretically available for conversion into work 336.2 B.t.u.

The B.t.u. corresponding to a horsepower is 2,545, which divided by 9.91 gives 256.8 B.t.u. as the heat actually turned into work per pound of steam. The efficiency is therefore 256.8 divided by 336.2, or 76.4 per cent.

Large Uniflow Engines for Rolling Mill

Uniflow engines have been installed for rolling mills in Germany, one of the largest on record having a maximum continuous capacity of 6,300 hp. and a short-duration peak-load capacity of 8,000 hp. The average load is 4,000 hp. This engine is a 67x55½ in., 120 r.p.m., and is installed at the Röchlingschen Steel and Iron Works at Völkingen. It was built by Erhardt & Sehmer, operating with 130 lb. pressure, superheat of 169 deg. F., and drives a 30-in. three-high mill. A like engine of 1,600 to 2,400 hp. capacity, 43x51 in., running at 120 r.p.m., is installed at the Rombacher Iron and Steel Works.

In this country the first uniflow engines for rolling-mill work are those now under construction by the Nordberg Manufacturing Co., Milwaukee, Wis., for the Youngstown Sheet and Tube Co., Youngstown, Ohio, the larger to drive a 12-in. rod mill, the smaller a 9-in. rod mill. The general design of the cylinders is shown by the longitudinal section of Fig. 2. The cylinder is a plain cylindrical casting, all valve chambers and steam passages being contained in the heads, bolted to the ends of the cylinder. This prevents distortion and strains due to expansion and contraction with the use of high pressures and superheats.

The steam valves are of the poppet type, the valve cages being separate castings ground into the heads with a steam-tight joint. The valves are of the double-beat, balanced poppet type, and no packing is required for the stems, which are ground and polished and work in ground and lapped bushings. The valves are operated from layshaft by a releasing valve gear with spring dashpots, the cutoff being under control of the governor through the wide range of loads. The steam enters the cylinder at the bottom, sweeping up over the heads and jacketing them before entering the valve at the top. The exhaust is through the ports in the center of the cylinder, uncovered by the piston near the end of its stroke. Relief valves of the poppet type with cataract dampening device are located near the bottom of the heads. With loss of vacuum and over-compression, these valves automatically open and connect the clearance space of the cylinder with the steam space in the head and the communicating steam piping. The steam conditions will be approximately 170 lb. pressure, 75 deg. superheat, and 20-in. vacuum, steam being condensed by barometric jet condensers.

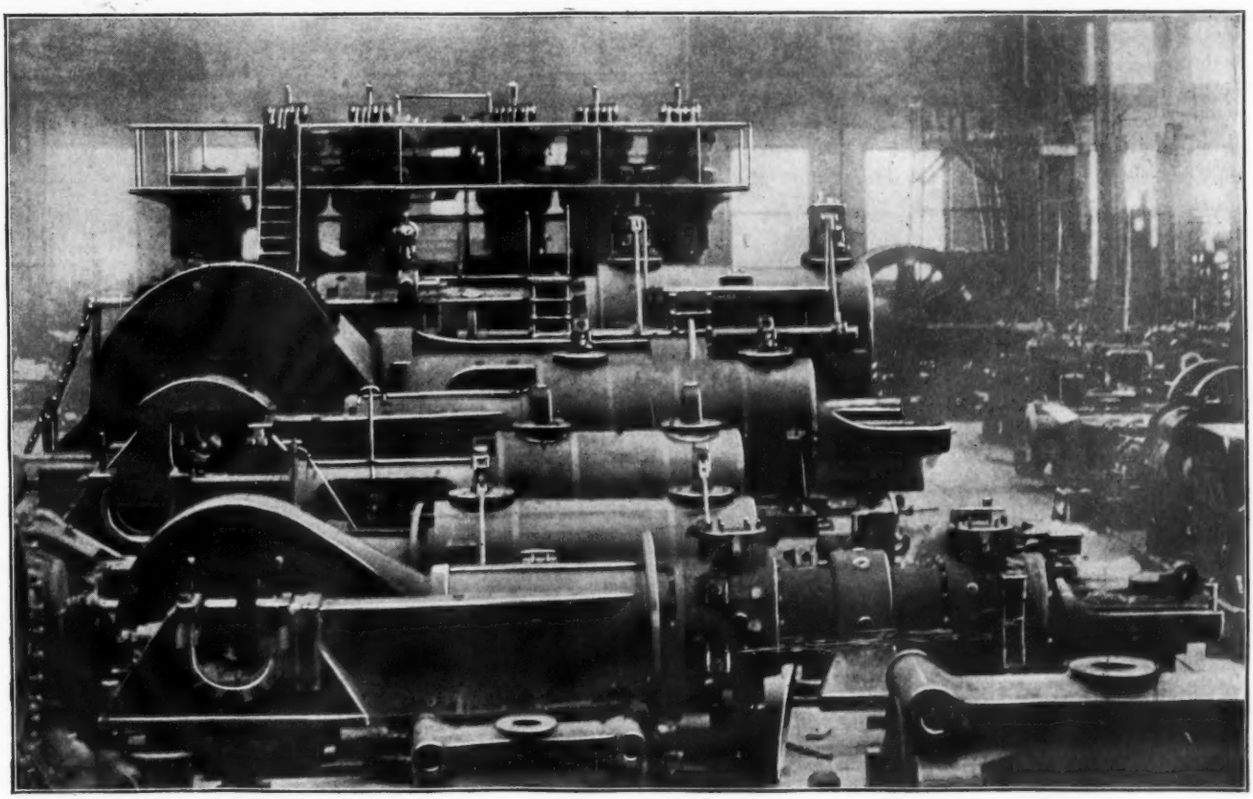


FIG. 1. SIX UNIFLOW ENGINES ON THE ERECTING FLOOR AT THE NORDBERG WORKS

The larger engine is 44x50 in., 110 r.p.m., and will have a capacity from 700 hp. to between 3,000 and 4,000 hp. The weight, including a 110,000 lb. 10-ft. flywheel, will be 480,000 lb. The second engine is a 37x48 in., 110 r.p.m., and weight, including a 90,000-lb. flywheel, will be 360,000 lb.

Fig. 1 shows six uniflow engines on the erecting floor at the Nordberg Works, the last two being the Youngstown engines. They are very large and appear big even in the background of the picture. One of the engines, the last one, is complete; the one next to it is without its cylinder. In the far background is a vertical five-cylinder 1,250-hp. Nordberg-Carels Diesel engine. In the foreground is a uniflow engine without the cylinder lagging and covering, which shows how the cylinder and head are built.

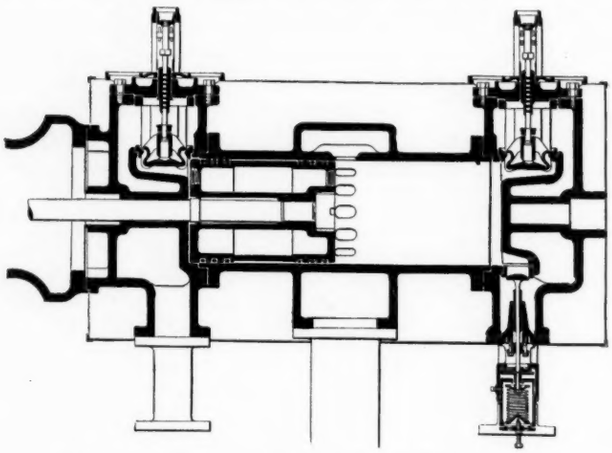
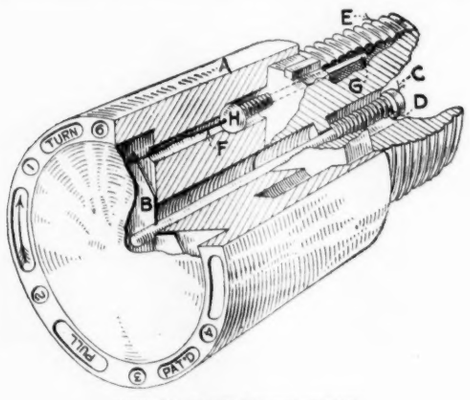


FIG. 2. SECTION THROUGH POPPET VALVE UNIFLOW ENGINE

A New Type of Fuse Plug

The illustration shows a new type of fuse plug, known as the Six-in-One, that has recently been placed on the market by the Atlas Selling Agency, New York, N. Y. This device consists of two parts. The upper revolving part *A* contains six chambers for six separate fuses, one of which is shown at *F* in the illustration. The top end of each fuse connects to a small triangular copper plate *B* which is mounted on a small rod that extends down to the bottom contact *C*. The bottom or rigid part *E* of the fuse is similar to the regular-type fuse plug, but instead of one end of the fuse wire being fastened to the metal thread, a small metal rod *G* connects to it by a flexible shunt. The rod extends up and is held by a spring in contact with a metal cap *H* to which the other end of the fuse connects in the revolving part. As can be seen, this completes the circuit from the metal thread *E* up through the fuse *F* and back through the central metal rod to the bottom contact *C*.



SIX-IN-ONE FUSE PLUG

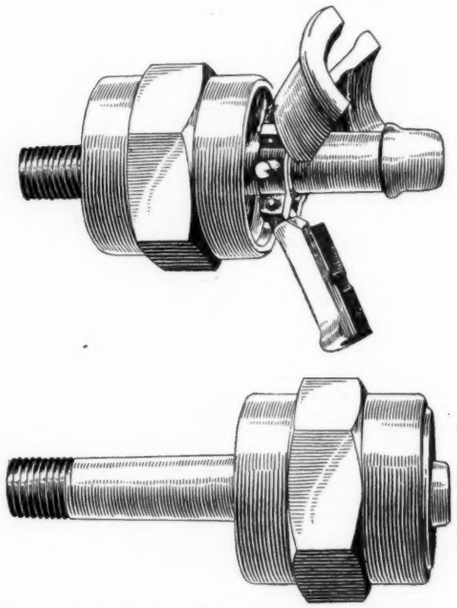
When a fuse burns out, all that is necessary is to pull slightly the rotating upper part which stands under the pressure of the spring *D*, move it to the right one-sixth of a turn, and another fuse is in circuit.

These plugs are made in sizes from 3 to 30 amperes and for 125 volts maximum.

The Elkin Hose Clamp

If there is one thing more than another that will cause an engineer to lose his temper, it is the leaking of joints and the blowing off of steam, gas or water hose. A clamp that can be quickly applied and one that firmly grips the hose is the Elkin, manufactured by Charles Elkin, 2875 Broadway, New York City.

The illustrations show the clamp as it appears before and after gripping the hose. It has a shank that fits in the bore of the hose, and three gripping fingers engage the hose on the outside. These are made with inside grooves about midway of their length that come opposite the projection on the nipple when the fingers are clamped to the hose. This grasps the hose firmly and prevents it from being pulled or blown from the coupling.



OPEN AND CLOSED POSITION OF HOSE CLAMP

The fingers are forced into position by a cap in which a spiral groove is cut on the inside to engage with a guide pin fitted to the clamping-arm frame. When the cap is turned, the pin causes it to move in one direction or the other, according to the direction in which it is turned, forcing the cap on or off the clamping fingers. When turned toward the clamping position, the cap is brought forward over the clamping fingers, forcing them tightly against the hose.

This clamp can be applied to any size or kind of flexible hose or tubing.

Kinds and Uses of Steam Traps

SYNOPSIS—The general characteristics of steam traps of the various classes are dealt with rather than the details of their construction and the illustrations are intended to show the operating principles of the class represented.

The function of a steam trap is to discharge water or allow its escape from the presence of steam without allowing the passage of steam also. The steam that may be seen when a trap discharges water to the atmosphere from a line under considerable pressure must not always be attributed to leakage of the valve or improper working of the trap. Water at the temperature of steam at any higher pressure contains much more heat than it does at atmospheric pressure, and the excess heat must be dissipated through the evaporation of some of the water into steam. Therefore a part of the "sure enough" water at high pressure and temperature becomes steam on being released from the trap.

From the nature of the service the outlet from a trap is often only slightly opened, and the wiredrawing is apt to cut the valve and cause it to leak, especially if the pressure is high or there should be grit present.

Steam traps in general operate either by the weight or by the buoyancy of the fluid or its temperature and are known as tilt, float and expansion traps. The tilt type depends on the weight of the accumulation of water to tilt the vessel containing it so as to actuate the valve for discharging it. In the float type water accumulates to a certain level in a vessel and by its buoyancy operates a float which in turn operates the discharge valve. Some, however, reverse the operation by utilizing the buoyancy of a bucket or empty open vessel inside of a closed vessel containing water to hold the valve closed, and when the water rises and overflows into the open vessel, its weight causes the latter to sink and thereby open the valve and discharge the water from the inside of the bucket, allowing it to float again and close the discharge valve.

Types Easily Distinguished

The most noticeable difference in these two types is that one oscillates on trunnions when the weight of water within it overbalances the adjustable counterpoised weight and by this change of position operates the various valves, while the other type is usually a closed cast-iron vessel with a float and outlet valve entirely inclosed and having no exterior moving parts. There are a few exceptions in which the float operates an exterior valve by a rod through a stuffing-box.

The thermostatic, or expansion, trap depends for its action on a change of temperature and the difference in the ratio of expansion between two metals or elements or the variable pressure exerted by a volatile fluid when subjected to different temperatures. This motion is communicated to the outlet valve of the trap by various means, but in all cases the action is the same. That is, when water accumulates in or about the trap and its temperature falls below that for which the trap is adjusted the more sensitive expansion element in the trap's composition contacts, causing the discharge valve to open, which allows the escape of the cooler water; but if water of high temperature reaches the trap it will not be discharged until it has become somewhat cooled. This feature is of value in some cases, as in a heater or radiator, because it permits the water to give up its heat before being discharged; while in other service, such as draining a steam line, it may be detrimental, as it is desirable to get rid of the water as promptly as possible.

Thermostatic traps are made in great variety. Some consist simply of a length of pipe, usually brass, with a valve on the end, the stem of which, having no thread, is attached to a fixed point and adjusted so that when the pipe has expanded to the limit determined by the temperature of the steam it contains, the valve will be seated, or closed. As the pipe contracts when the water in it cools, the stem of the valve remaining fixed, the valve is opened slightly by the contraction of the pipe, allowing the water to escape until the pipe's expansion again closes the valve. Numerous modifications in construction are on the market, but all depend on the same principle.

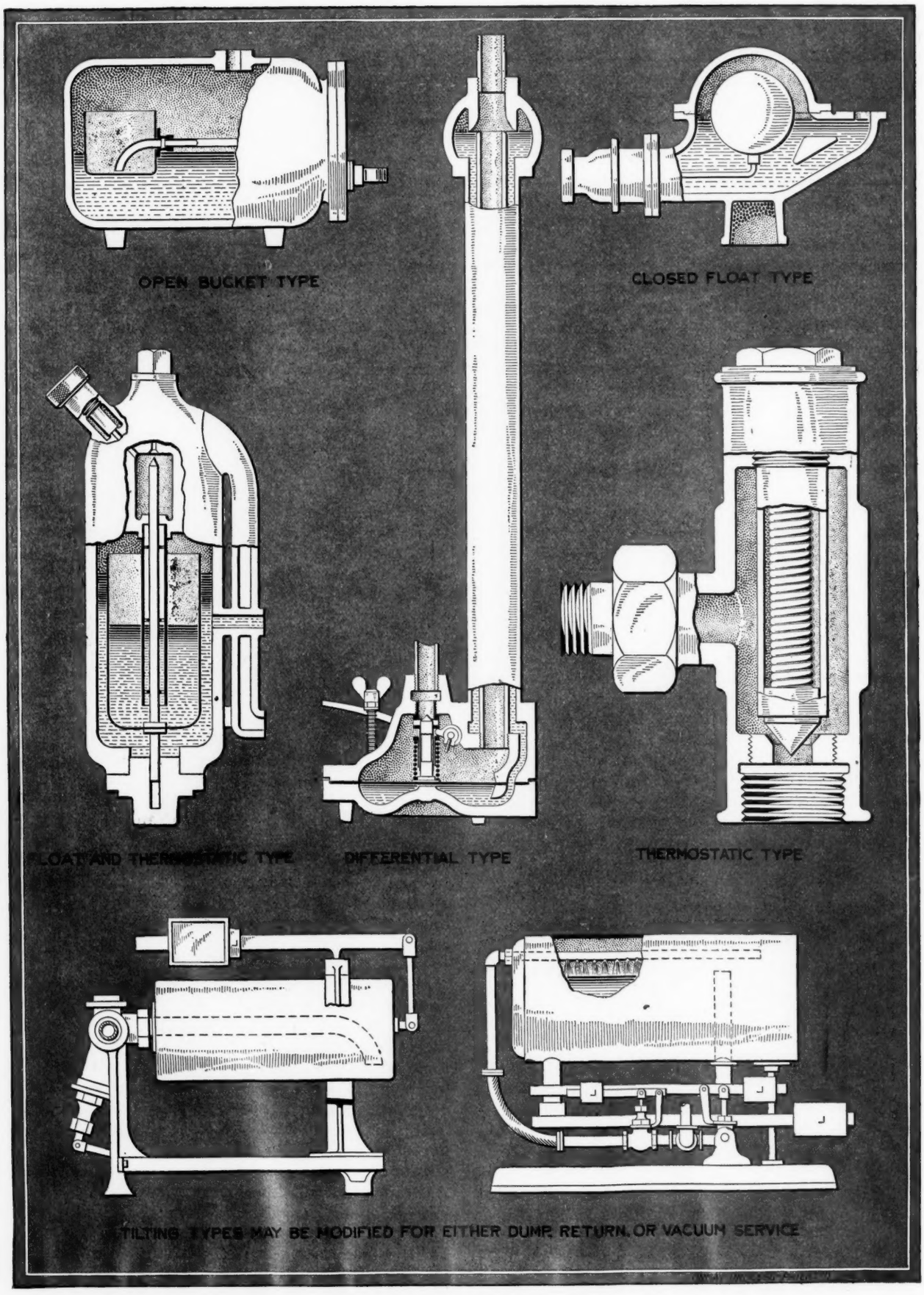
The diaphragm type of thermostatic trap utilizes the force exerted by a volatile fluid confined in a tight container having one or more flexible sides that move outward as the pressure exerted by the fluid or gas within increases with an increase in temperature. Any change in the temperature of the water in contact with this member will cause the amount of discharge opening to vary correspondingly. This type is extensively used for draining individual radiators and similar service.

A Type Not in Such General Use

The differential type is designed to maintain a difference in the level of the fluid in two vertical pipes, that is, a static head of water in one pipe tends to hold the discharge valve closed while that in the other tends to open it and an adjustable tension spring assists or retards the action of the discharge valve and by its adjustment any difference in the water level in the two pipes may be obtained, within the capacity of the trap. In this trap the headroom required is considerable since a column of hot water upward of 2½ ft. high is only equal to 1 lb. pressure and since this pressure difference constitutes the active principle it should be as great as possible.

Steam traps are divided, according to the service performed, into two classes—separating, or "dump," traps and return, or pressure-discharge, traps. The former, as the name implies, are used to separate the condensate from the steam and simply dump it into a receptacle or waste pipe usually at about atmospheric pressure. Most nontilting, or pot, traps and all thermostatic traps fall under this general head, while the tilting type may be fitted for either service.

Return, or pressure-discharging, traps are used to deliver the water against pressure (as into a boiler by being located 3 ft. or more above the level of the water in the boiler) and when discharging they receive steam at full pressure from the boiler to the space above the water in the trap, thus equalizing the pressure and allowing the water to descend into the boiler by gravity. They are sometimes used to deliver to an elevated tank against


OPEN BUCKET TYPE
CLOSED FLOAT TYPE
DIFFERENTIAL TYPE
THERMOSTATIC TYPE
TILTING TYPES MAY BE MODIFIED FOR EITHER DUMP, RETURN, OR VACUUM SERVICE

ONE SPECIMEN TRAP, ILLUSTRATING THE OPERATING PRINCIPLE, OF EACH CLASS REPRESENTED

static head only. The promptness with which the trap will discharge depends on the elevation (if discharging into the boiler) and the size and directness of the connecting pipe.

Traps of this type may be located below the boiler to be fed, so that low-pressure returns will flow into them, provided steam of a higher pressure than that in the boiler to be fed is available from some other source to discharge the trap. Otherwise two traps must be used, the first to receive the low-pressure returns at a low level and deliver the water to a similar trap in an elevated position, as described; or the receiving trap may discharge into an elevated tank fitted with a steam connection and a valve connected to, and operated by, the trap, but opposite in point of time, so that when the trap is discharging there is no pressure on the elevated tank, and while the trap is filling the elevated tank is under pressure and discharging the water into the boiler. The steam valve on the tank may be a reverse-acting diaphragm valve, connected by a small pipe to the steam supply of the trap, so that when the pressure is on the trap discharging it, there is also pressure on the diaphragm holding the tank valve closed, and when the trap is in the other position for filling, the pressure is off the diaphragm of the valve, allowing it to open and admit steam to the tank.

Water may be discharged from the ordinary dump trap to a height equal to the pressure of steam in the line drained by the trap, multiplied by the weight of water per foot in height, or pressure multiplied by 2.3 to 2.5 (according to the temperature), a fact often lost sight of.

Connecting Traps to Vacuum Lines

Vacuum traps are used to drain a system of pipes, a condenser or other vessel under a pressure below that of the atmosphere. They cannot be vented by the ordinary air vent to the atmosphere, but instead, there must be a pipe connection from the upper part of the trap to the condenser or to some point where the pressure is as low as or lower than the vessel to be drained. Discharging the water is done by breaking the vacuum in the trap and allowing the water to flow out or by admitting steam and forcing it out, as in the return trap. In some steam traps a vacuum is formed within the trap by the introduction of a jet of cold water directly into the chamber of the trap. With a vacuum within a return trap during the filling period, low-pressure returns may be brought to it when it is elevated (within certain limits) sufficiently to allow it to discharge into the boiler, without the use of a two-trap system as described. The use of a vacuum is applied only to traps having means of admitting pressure (air or steam) for discharging the water from them or a discharge tail pipe with sufficient drop to exceed the degree of vacuum maintained in the trap.

All types of traps must be so connected or fitted that air will not accumulate in or near them to such an extent as to interfere with their filling promptly. Thermostatic traps are not subjected to this difficulty. Tilting traps generally, and a few of the pot type, are fitted with small valves that open directly to the atmosphere (or to a vacuum line) while the trap is filling, thus avoiding all back pressure. Otherwise they must be fitted with automatic air vents or with small vent cocks left open slightly to relieve the air and usually to blow a little steam to avoid becoming airbound.

Air vents on radiators are simply miniature steam traps usually combining the float and thermostatic principles. The float in this case closes the vent instead of opening it when water is present. Larger traps are also sometimes made to embody two of the principles of action described.

When put to their proper use all types of traps—like some other things we hear of—are good, but some are better than others for a particular service, and all require a "mint" of good judgment and care to be at their best.

Stevens Underfeed Stoker

The attention that is being given to boiler-room economies has been the incentive among manufacturers of several types of stokers to perfect them for use with small-capacity boilers, say of 60 hp. and upward. Among these is the Stevens underfeed stoker, manufactured by the Nelson Blower and Furnace Co., 11 Elkins St., Boston, Mass.

The engineer of a small-capacity steam plant should be interested in increased efficiency and increased boiler capacity, in the elimination of smoke and in reduced fuel

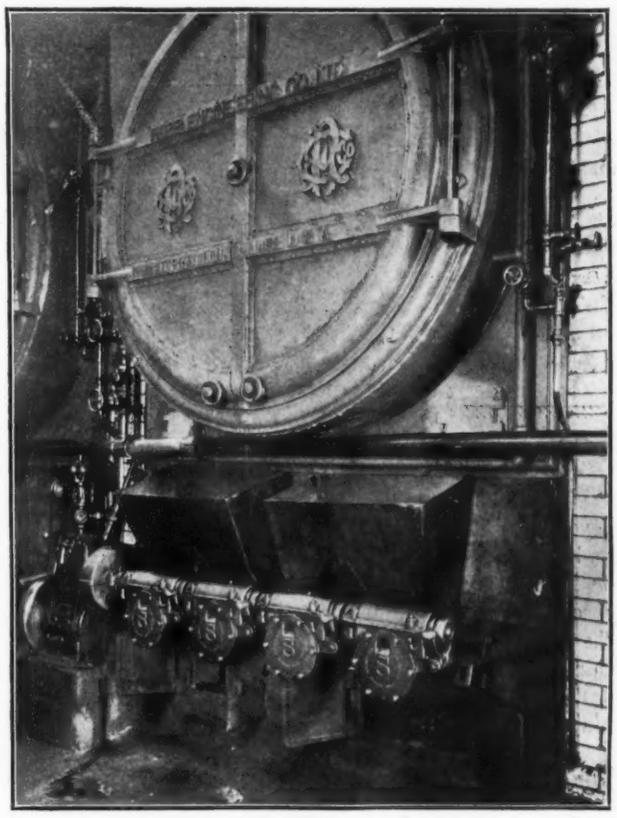


FIG. 1. STEVENS STOKER ATTACHED TO BOILER FRONT

bills, in the economical burning of low-grade fuel and in maintaining an even furnace temperature. All of these features are claimed for the Stevens stoker, besides simplicity in design and construction and small maintenance expense.

The design of this stoker is such that it can be placed under any boiler without disturbing the side walls or bridge-wall and without excavating the ashpit or in front of the boiler. The general appearance of the device

as it looks when attached to the front of a return-tubular boiler is shown in Fig. 1.

An important feature of this stoker is the removable coal hopper that is fitted to the outer end of the worm trough. In the event of any derangement to the stoker, the hopper can be removed and the boiler fired by hand the same as if the stoker had never been installed. With this simple arrangement the possibility of any failure to maintain a steam pressure because of stoker troubles is avoided.

The apparatus comprises a trough or troughs, according to the size, open at the top and extending from a short distance outside the boiler front to the rear of the furnace. In the bottom of each trough is a screw conveyor which is driven from the outer end by a worm gear and worm, the latter being driven by a small steam engine or motor. As the screw conveyor revolves, the fuel is spread evenly over the grate surface. The grates are of the dumping and shaking type. Fig. 2 shows a plan and side view of the stoker. The stoker and grates are also designed for round furnaces such as used with the Manning type of boiler.

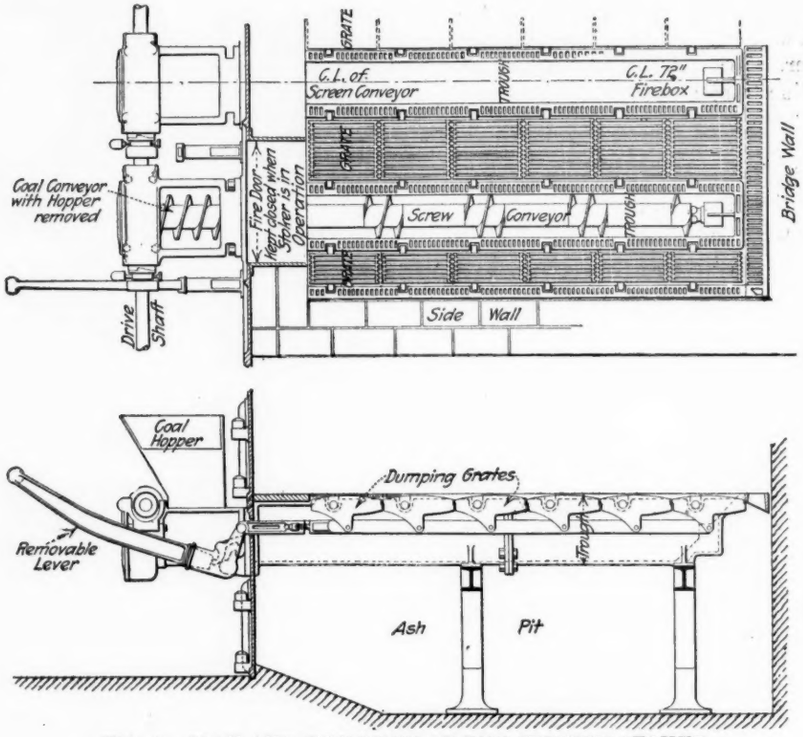


FIG. 2. PLAN AND SIDE VIEW OF THE STEVENS STOKER

Horsepower Constant is the number of horsepower per pound of mean effective pressure developed by an engine when running at its normal speed. It will be different for different speeds. Knowing the constant, one need only multiply the mean effective pressure (obtained from an indicator diagram) by this constant to know what indicated horsepower the engine is developing. Evidently by the definition, the horsepower constant is all of the "PLAN" formula except the P.

Brass-Polishing Paste, said to give satisfactory results is composed of camphor gum, 1 oz.; alcohol, 2 oz.; spirits of ammonia, 4 oz.; spirits of turpentine, 4 oz.; candle paraffin, 1 lb.; clean tallow, 1 lb.; tripoli, 1 lb. For compounding, first dissolve the camphor in the alcohol, then melt down the tallow and paraffin and stir in the liquids and the tripoli. Before cooling, the paste can be packed in boxes of sizes convenient for use.

Gas Power in England

By F. R. Parsons

Consequent upon the steady but insistent rise in the price of anthracite and gas coke, users of small and medium-sized gas-power plants in England are anxiously concerned as to future developments. Time was, not so long ago, when the price of solid fuel permitted the production of gas power at a figure otherwise practically unrealizable, except in rare instances, by the use of town's gas; and the resultant boom in the manufacture of suction-gas plants, both in England and abroad for the home markets, bid fair to mark a new and important epoch in industrial progress.

With good-quality anthracite then procurable miles away from the collieries, at 26s. ($6.30) per ton, one brake horsepower-hour, calculated upon the usual basis of 1.5 lb. of fuel per horsepower-hour could, at a cost for fuel only, be developed for 0.216d. (0.438c.) or including labor and fixed charges for about 0.402d. (0.816c.).

But let us see with what a gas-power user here in England has to contend today. Before me is a quotation from a coal dealer offering to supply anthracite in weekly 2-ton lots at 49s. 6d. (approximately $12) per ton delivered. But this quotation becomes a mere travesty when one reads the footnote, which runs as follows: "We make no guarantee whatever to supply this or any quantity, and purchasers must clearly understand that as we are entirely in the hands of the collieries and hold no stock, we put ourselves entirely outside the limits of responsibility consequent upon delays or nondelivery. Orders are accepted only on this understanding."

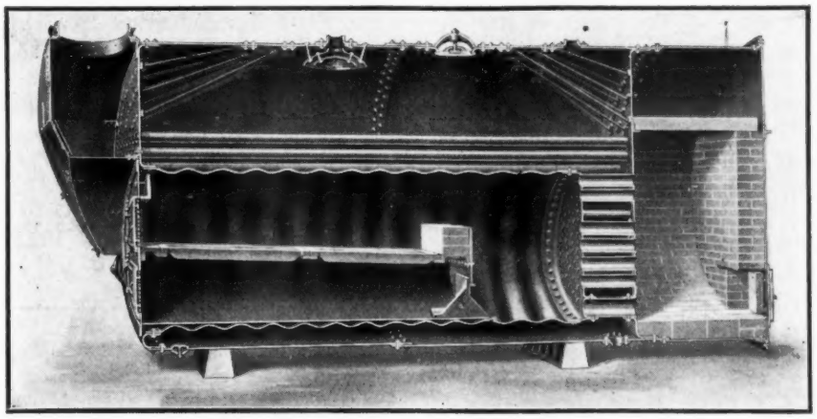
It must be admitted that this is not very consoling to a power user who is dependent for the supply of his fuel upon such flimsy and indefinite promises. And this apart from the equally important advance in price, which curtails to a very great extent, if not altogether, whatever advantages were formerly possessed by gas-producer plants.

But assuming price to be the only unfavorable factor, let us see how that alone affects alternative power schemes today. Granted that the price of town's gas has been generally increased as a consequence of labor difficulties and the many and unprecedented contingencies incidental to the war, it will be admitted that the rise has been small compared to the rise in the price of solid fuel for suction-gas producers.

Taking 49s. 6d. per ton as the basis of calculations and assuming a consumption of 1.5 lb. per brake horsepower-hour, the fuel cost alone amounts to 0.390d. (0.79c.). Then adding to this the labor and fixed charges as before, the productive cost reaches a total of 0.576d. (1.17c.) per brake horsepower-hour. Comparing this figure with the alternative cost of town's gas, we find that this is practically equivalent to town's gas at 30.19d. (61c.) per thousand cubic feet.

The Murray "Duplex" Boiler

The chief aim in designing the Murray "Duplex" internally fired boiler was to overcome the universal disadvantage of the Scotch boiler, namely, poor circulation (heating) in that part below the line of the fuel bed and resultant stresses due to unequal expansion and contraction. The aim second in importance was to do away with flat surfaces (except at the heads). The Murray Iron Works, Burlington, Ia., are the builders.



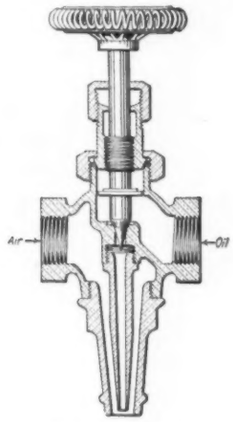
SECTION OF THE MURRAY DUPLEX BOILER

It will be remembered that in the most common type of Scotch boiler the gases leave the grate, flow away from the observer to the back connection, then turn up and pass to the front end of the boiler through tubes above the corrugated furnace. As shown in the illustration, the gases in the Murray boiler pass through short tubes surrounded by water before getting to the back connection and making the forward sweep to the front of the boiler through the long tubes. The tendency is, of course, to highly heat the water surrounding these short tubes and thereby establish and maintain circulation throughout the boiler.

There is no crown-sheet such as we know it in the Scotch boiler. The shell is plain cylindrical, and the furnace may be either corrugated or of the Adamson type, depending upon the pressure to be carried. The shell plates have a tensile strength of from 55,000 to 62,000 lb., not less than 50 per cent. ductility and 25 per cent. elongation. The boilers are built for capacities of 8 to 250 hp. and for pressure of 100 to 200 lb. Particulars of the larger sizes are given in the table.

Powell Oil Burner Valve

The Powell oil burner valve is illustrated in section herewith. The oil tube and air nozzle are designed to produce the maximum amount of heat with a minimum amount of oil and air; there is a free and unobstructed passage for the oil. The valve can be used where the injection is provided by air from a compressor, blower or fan blast or by steam.



OIL BURNER VALVE

The flow of oil is controlled by the needle-pointed valve stem. The valve when in the pipe line is connected between two ordinary valves, which control the flow of oil and air.

The valve is made by the William Powell Co., Cincinnati, Ohio.

Heat Losses from Buildings comprise the radiation of heat through walls, windows, skylights, floors and roofs but only such parts of individual rooms are included, in calculating the radiation required, as are exposed to lower temperatures than that of the room under consideration. Partitions and floors between rooms to be heated are not considered. Where floors or walls are below grade, the temperature of the ground should be taken at about 40 deg. and not the lowest outside air temperature. Air spaces in walls or under the roofs and double windows with an air space reduce the losses by radiation considerably.

SIZES AND WEIGHTS OF THE "DUPLEX" BOILER

All with corrugated furnaces, cast cradles and trimmings

Horse-power	Diameter	Length	Furnace No.	Furnace Diameter	Tubes No.	Tubes Size	Auxiliary Tubes No.	Auxiliary Tubes Size	S.W.P., Lb.	Thick-Steel Shell	Thick-Steel Head	Weight, Lb.	Longitudinal Joint
50	6 ft. 3 in.	12 ft. 8 in.	1	36 in.	48	3 in. x 9 ft. 6 in.	38	4 in. x 15 in.	100	3/8 in.	9/16 in.	13,300	TRBS*
							1	6 in. x 15 in.	125	7/16 in.	5/8 in.	15,000	QRBS†
									150	1/2 in.	11/16 in.	17,000	QRBS†
75	6 ft. 6 in.	14 ft. 8 in.	1	36 in.	42	3½ in. x 11 ft. 6 in.	38	4 in. x 15 in.	100	3/8 in.	9/16 in.	15,400	TRBS
							1	6 in. x 15 in.	125	7/16 in.	5/8 in.	17,500	QRBS
									150	1/2 in.	11/16 in.	20,000	QRBS
100	7 ft. 0 in.	16 ft. 2 in.	1	38 in.	56	3½ in. x 12 ft. 6 in.	47	4 in. x 15¼ in.	100	3/8 in.	9/16 in.	19,000	QRBS
							1	10 in. x 15¼ in.	125	7/16 in.	5/8 in.	21,500	QRBS
									150	1/2 in.	11/16 in.	24,500	QRBS
125	7 ft. 6 in.	16 ft. 2 in.	1	45 in.	70	3½ in. x 12 ft. 6 in.	64	4 in. x 15¼ in.	100	7/16 in.	9/16 in.	21,500	QRBS
							1	10 in. x 15¼ in.	125	1/2 in.	5/8 in.	25,000	QRBS
									150	5/8 in.	11/16 in.	28,000	QRBS
150	8 ft. 0 in.	16 ft. 8 in.	1	50 in.	80	3½ in. x 13 ft. 0 in.	76	4 in. x 15¼ in.	100	7/16 in.	9/16 in.	25,000	QRBS
							1	10 in. x 15¼ in.	125	1/2 in.	5/8 in.	29,000	QRBS
									150	11/16 in.	11/16 in.	32,000	QRBS
200	9 ft. 6 in.	16 ft. 3 in.	2	38 in.	108	3½ in. x 12 ft. 6 in.	94	4 in. x 15¼ in.	100	1/2 in.	9/16 in.	36,000	QRBS
							1	10 in. x 15¼ in.	125	9/16 in.	5/8 in.	41,000	QRBS
									150	3/4 in.	11/16 in.	45,000	QRBS
250	10 ft. 6 in.	16 ft. 3 in.	2	45 in.	137	3½ in. x 12 ft. 6 in.	128	4 in. x 15½ in.	125	5/8 in.	9/16 in.	44,000	TRBS
							2	10 in. x 15¼ in.	125	3/4 in.	5/8 in.	50,000	QRBS

Fittings and fixtures consist of cradles, doors, grates and steam trimmings as listed in specifications.
*Triple-riveted butt strap. †Quadruple-riveted butt strap.

Locomotive Indicator Diagrams

By M. C. M. Hatch

SYNOPSIS—Some interesting figures and diagrams obtained from tests run with a freight locomotive. The diagrams are numbered to correspond with similar ones on a profile diagram of the division over which the tests were run.

It occurred to the writer that perhaps some of the brethren who keeps the turbines whirling might be interested to see what goes on inside the cylinders of a thoroughly modern locomotive. The locomotive in question, Fig. 1, was of the Pacific type, having 25x28-in. simple cylinders, 69-in. driving wheels and carrying 200 lb. of steam. A Schmidt double-loop superheater is used, and the firebox has a brick arch of approved design. The total weight of the engine is 291,000 lb., of which 188,000 lb. rests on the drivers. The boiler provides a total heating surface of 3,466 sq.ft., of which 289 is in the firebox and combustion chamber, and the total grate area is 58 sq.ft. The calculated maximum tractive effort at the rail is, for an engine of these characteristics, 43,100 lb., and the maximum cylinder horsepower reached, with superheated steam, at a piston speed of about 1,000 ft. per in., is 2,252.

The tests were conducted in manifest freight service over a division 140 mi. long, the profile of which is shown in Fig. 2. Small figures on this profile, which correspond to the numbers of the diagrams, Fig. 3, will indicate where they were taken. A second engine, of the consolidation type, was used as a pusher over the part of road shown by a double line. A first-class dynamometer car, indicating at all times the amount of work the engine was doing at the tender drawbar, was part of the test train, which consisted of 44 cars with a weight of 1,520 tons.

With coal of a calorific value of 13,900 B.t.u. per lb., dry, an equivalent evaporation of 9.32 lb. of water per hour was reached, the over-all boiler efficiency being about 65.1 per cent. The average superheat was 160 deg. and the quality of steam in the dome 97.5 per cent. dry

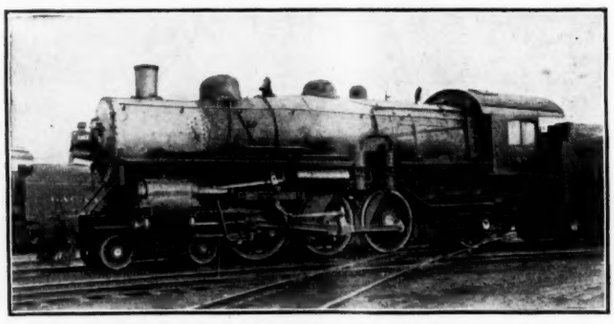


FIG. 1. PACIFIC-TYPE LOCOMOTIVE

under hard-working conditions. Including the supply for all auxiliaries such as the air-brake pumps, etc., the dry steam per drawbar horsepower-hour amounted to 28.09 lb. On the basis of indicated horsepower this would give a steam consumption of about 21.7 lb. of dry steam, or 3.05 lb. of dry coal per 1 hp.-hr. Considering diagram No. 12, Fig. 3, we find that, to sustain 2,186 i.hp. (97 per cent. of the theoretical maximum), there must be burned per hour 6,667 lb. of dry coal, or 6,862 lb. of coal as fired. This corresponds to a fuel rate, as fired, of 118.3 lb. of coal per square foot of grate surface per hour, the corresponding actual evaporation per square foot of heating surface per hour being 13.69 lb. and the equivalent evaporation 17.92 lb., a boiler horsepower thus being developed, at the given rate of forcing, for each 1.93 sq.ft. of heating surface, the boiler delivering 1,796 hp. Are many stationary boilers called upon for such a performance?

Getting back to the diagram, it should be stated that the 14-in. piston valves are actuated by Walschaert gear

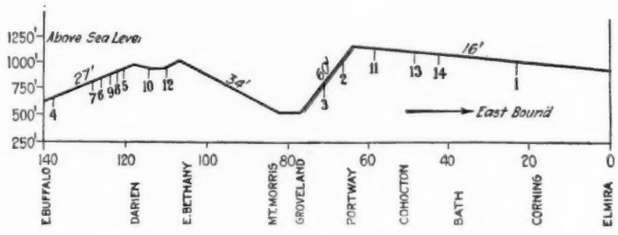


FIG. 2. PROFILE OF 140 MILE DIVISION

and have 6½ in. maximum travel, $1\frac{1}{16}$ steam lap, $\frac{3}{16}$ in. exhaust clearance and $\frac{3}{16}$ in. constant lead. An outside spring indicator with a simple form of reducing motion was used, all piping was carefully put up and protected, and in general, the endeavor was made to get the work as accurate as possible under the somewhat difficult conditions of locomotive road-test work. It will be seen that the diagrams shown cover speeds from starting up to 54 mi. per hr. and cutoffs from 82 to 27 per cent. of the stroke, about the total range of working cutoffs which are used.

Full throttle, the approved way of working a superheater locomotive, was used on all diagrams except No. 1, the starting card, throttling being necessary in this case to prevent slipping while getting a heavy train into motion. Steam-chest pressure is shown on several of the diagrams, the fluctuation of which is not excessive for locomotive practice, indicating sufficient area through the throttle, superheater and steam pipes and also that the steam-chest volume is adequate to supply the demands of the cylinders when the ports are opened. In passing, the writer may say that on another railroad he had some sad experience with a certain class of large passenger engine whose steam passages and volumes were so restricted that the indicator showed drops of 50 lb. pressure in the steam chest when the valves opened. The back pressure shown is about normal for a locomotive, the engine in question exhausting through a $6\frac{7}{16}$-in. diameter circular single nozzle. The high compression of the last diagrams is typical of short cutoff high-speed locomotive work.

In general the table is self-explanatory, but mention may be made of the lines "Drawbar Pull" and "Tractive Effort." These terms are often used (erroneously) as synonyms. Tractive effort is the total turning moment at the periphery of the drivers where they rest on the rails, while drawbar pull is the actual draft on the drawbar at the rear of the tender, as measured by a dyna-

TYPICAL INDICATOR CARDS

Cylinders, 25x28 In. Driving Wheel, 69 In. Boiler pressure, 200 Lb. Theoretical Tractive Effort, 43,116. Cylinder hp. at 1,000 Ft. Piston Speed, 2,252. Indicator Spring, 1 In. = 100 Lb.

	Diagram No.													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Location	285.7	329	334.3	402.3	383	390	392	384.8	388	377	321	374.8	312.3	307
Throttle position	0.75	F	F	F	F	F	F	F	F	F	F	F	F	F
Cutoff, in.	23	16.3	16.3	15.6	16	16	16	16	12.3	14.8	9.2	14.8	7.6	7.6
Boiler pressure	187	196	200	196	191	196	196	196	196	196	196	196	200	193
Revolutions per minute	Start	73.07	84.03	92.55	114.69	124.21	137.61	153.44	181.45	194.84	216.76	227.72	238.68	263.03
Speed, mi. per hr.	Start	15	17.25	19	23.75	25.5	28.25	31.5	37.25	40	44.5	46.75	49	54
Speed, piston, ft. per min.	Start	340.5	391.5	431	534	579	641	715	845.5	908	1,010	1,061	1,112	1,225
Drawbar pull	36,100	25,000	25,000	25,500	21,500	20,500	22,000	18,500	12,500	14,000	10,500	13,500	8,500	7,000
M.e.p., head end	149	134	133	125	105	103	104	85	59	72	51	65	39	39
M.e.p., crank end	152	139	135	128	111	106	113	96	65	77	59	74	47	40
Back pressure	8	7	9	9	12	13	8	15	12	17	9	11	9	10
Steam-chest pressure	....	188	184	176	178	174	172	171	185	180	188	....	....	176
Tractive effort	38,175	34,650	33,975	32,050	27,400	26,475	27,500	22,950	15,730	18,900	13,950	17,625	10,910	10,020
Tractive effort per cent. of theoretical max.			78.7	74.3	63.5	61.3	63.7	53.2	36.4	43.8	32.3	40.8	25.3	23.2
I.hp. both engines, total	....	1,376	1,556	1,617	1,712	1,798	2,062	1,920	1,558	2,006	1,648	2,186	1,420	1,436
Drawbar horsepower	....	1,000	1,150	1,327	1,362	1,394	1,645	1,553	1,242	1,493	1,247	1,683	1,108	1007
Machine efficiency, per cent.	....	72.6	73.8	82.0	79.5	77.5	79.8	80.8	79.7	74.4	75.6	77.1	78.0	70.1

mometer, available for moving a train. The difference between the two is of course the amount of the total power of the engine necessary to move itself and its tender. The measure of this is shown in the last line "Machine Efficiency," giving the percentage of the total power of the unit which can do useful work. As a matter of interest it may be stated that the thermal efficiency of the locomotive used in the test figured out about 4.75 per cent.

Modern locomotives lead a strenuous life. Much in the way of power output is demanded of them, and in all fairness it must be said that they respond nobly to that demand. Inexorably restricted, by clearance and weight limitations, as to size, they will generate a horsepower, as this particular engine does, for each 133 lb. weight. What will the average stationary plant show when prime movers, generators, boilers, auxiliaries, etc., all are considered, as they should be? I have no figures in mind in regard to this, but should very much like to know. On the "economy" basis the multi-expansion condensing unit can of course show far better results but I believe that when it comes to "efficiency," which we must have on our railroads today more than ever, the modern steam locomotive, an absolutely self-contained power plant, is not the lamentable makeshift that many seem to delight to proclaim it.

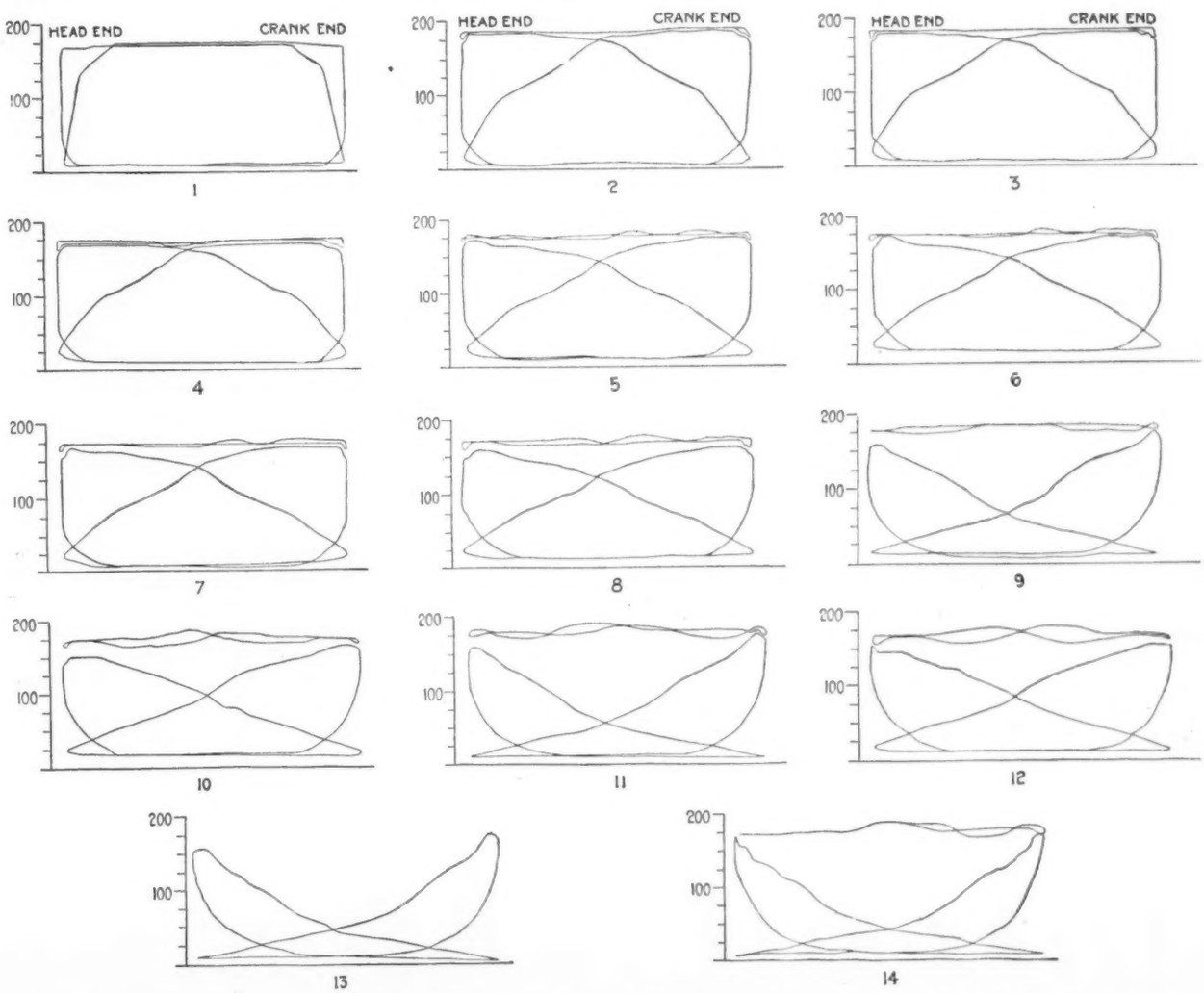


FIG. 3. INDICATOR DIAGRAMS, THE NUMBER OF WHICH CORRESPOND TO THOSE ON THE PROFILE, FIG. 2

Flow of Oil Through Orifices

SYNOPSIS—Measurements of flow with fuel oil, power distillate and Kansas crude under different pressures and with different sized orifices.

With a view to obtaining some data applicable to the design of oil-injection devices, investigations were conducted last year at the State University of Iowa, into the flow of oil through orifices, the results forming the subject of a prize thesis by G. P. Anthes. Experiments were made at a constant temperature of 70 deg. F. with samples of fuel oil, power distillate and Kansas crude, six pressures ranging from 10 to 350 lb. and five orifices ranging from 0.0232 to 0.0807 in. diameter. Additional tests in which the temperature was varied were made on heavy steam-engine cylinder oil.

The flow of oil may be represented by the formula

$$Q = CA\sqrt{2gH}$$

where Q is the discharge in cubic inches per second, C is the coefficient of discharge, A the area of the orifice in square inches, $g = 32.16$ and H is the head in feet.

Reduced to terms of pressure and specific gravity, the formula may be expressed as

$$Q_{70} = 146CA\sqrt{\frac{P}{G_{70}}}$$

where Q_{70} and G_{70} represent the discharge and specific gravity respectively, at the standard temperature of 70 deg. F., and P is the pressure acting on the oil in pounds per square inch. The values of C for the test conditions are given in the table, and the actual discharge in each case by the curves, Figs. 1 to 3.

Fuel oil was tried at extremes of temperature, at a number of pressures and with several orifices, but there was no apparent change in the discharge between the extremes of temperature, it remaining practically the same as at 70 deg. F.

COEFFICIENTS OF DISCHARGE

Diameter of Orifice, In.	10	25	75	150	275	350
		Pressure Pounds per Square Inch				
Fuel Oil, 70 Deg. F.						
0.0232	0.70	0.68	0.67	0.66	0.65	0.65
0.0305	0.69	0.67	0.66	0.65	0.64	0.64
0.0425	0.68	0.66	0.65	0.64	0.64	0.63
0.0630	0.67	0.65	0.63	0.63	0.62	0.62
0.0807	0.63	0.63	0.63	0.62	0.61	0.61
Power Distillate, 70 Deg. F.						
0.0232	0.70	0.68	0.67	0.66	0.65	0.65
0.0305	0.69	0.67	0.66	0.65	0.64	0.64
0.0425	0.68	0.66	0.65	0.64	0.62	0.63
0.0630	0.67	0.65	0.63	0.63	0.62	0.62
0.0807	0.63	0.63	0.63	0.62	0.61	0.61
Kansas Crude Oil, 70 Deg. F.						
					250 lb.	
0.0232	0.73	0.71	0.70	0.69	0.68	0.67
0.0305	0.71	0.69	0.68	0.67	0.66	0.65
0.0425	0.70	0.68	0.67	0.66	0.65	0.65
0.0630	0.69	0.67	0.66	0.65	0.64	0.64
0.0807	0.65	0.65	0.64	0.63	0.63	0.63

Interesting results were obtained, however, with the steam-cylinder oil. Observations were made in which the temperature was varied from 50 to 200 deg. F., using the 0.063-in. orifice and pressures from 10 to 250 lb. It was found that there was a temperature at each pressure

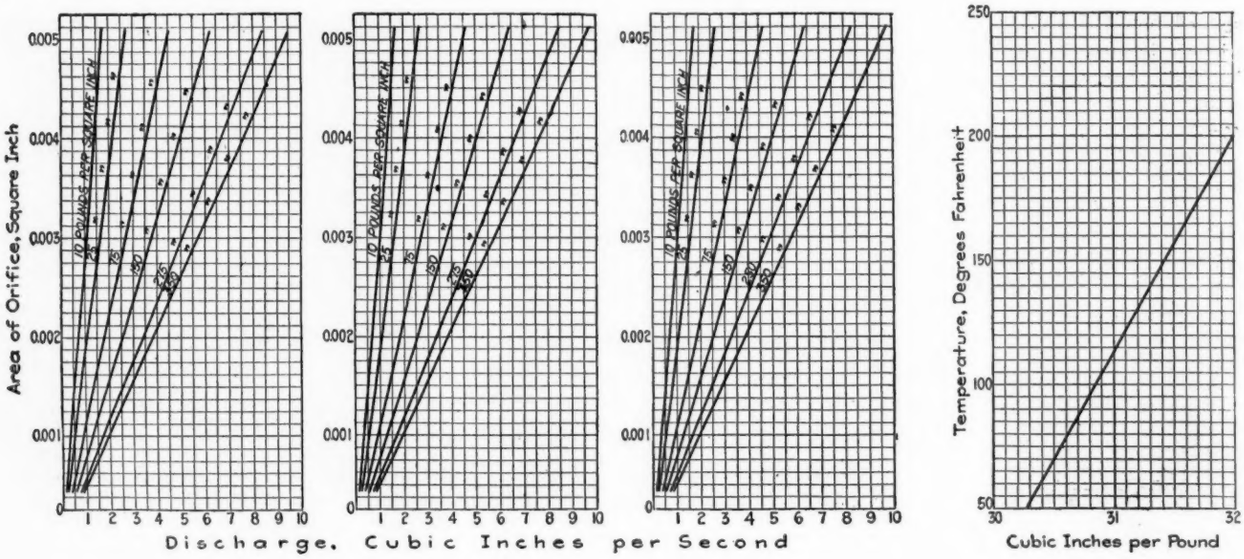


FIG. 1. FUEL OIL, SPECIFIC GRAVITY 0.835

FIG. 2. POWER DISTILLATE. SPECIFIC GRAVITY 0.825

FIG. 3. KANSAS CRUDE OIL, SPECIFIC GRAVITY 0.851

FIG. 4. STEAM-CYLINDER OIL, VOLUME PER POUND

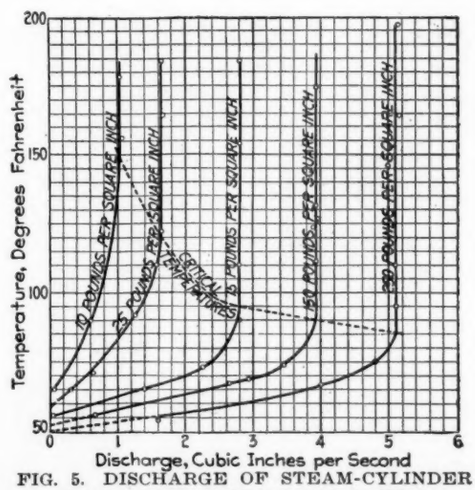


FIG. 5. DISCHARGE OF STEAM-CYLINDER OIL AT DIFFERENT TEMPERATURES

above which the discharge became independent of the temperature and below which the discharge drops off at an increasing rate with a decrease in temperature. These critical temperatures decreased as the pressure increased. Fig. 4 shows the relation between temperature and cubic inches per pound of this heavy oil, and Fig. 5 gives the discharge.

A striking indication of the results is that the discharge per second above the critical temperature is in all cases nearly the same as the discharge for eight oils at 70 deg. F. This would point to the fact that no matter what kind of oil be used, the discharge from a given orifice with a given pressure is always the same if the oil be at or above its critical temperature.

A Conventional Representation of an Induction Motor

SYNOPSIS—A conventional method of representing the induction motor that shows the reason for the distribution of the rotor current.

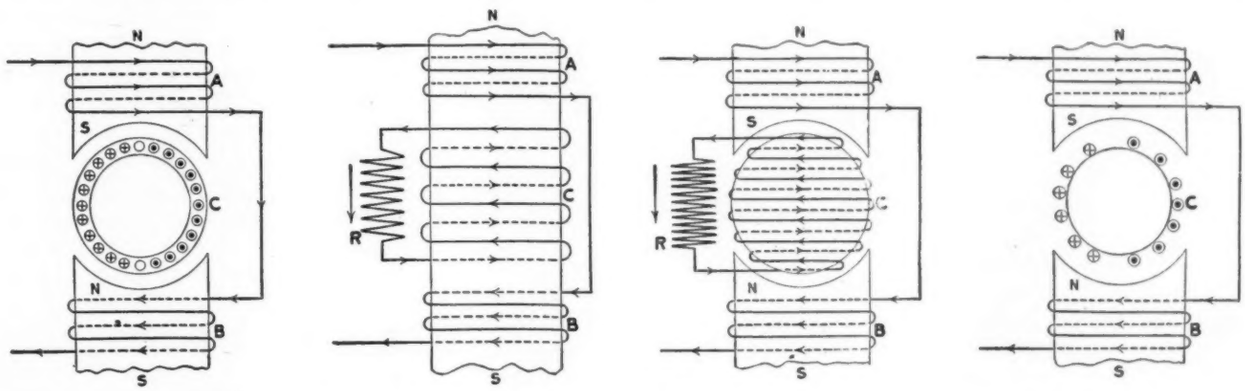
The conventional diagram in Fig. 1 is frequently used to illustrate the induction motor. The stator or primary winding and core are represented by *A* and *B*, while the circles represent the conductors on the rotor or secondary *C*. Direction of current toward the reader is indicated by the dots in the center of the circles; the crosses indicate direction down through the plane of the paper. Why the rotor current will be distributed as in the figure is something that may cause more or less difficulty for those not familiar with this kind of diagram. The object of this article will therefore be to discuss this particular point.

To determine the direction of an induced current or electromotive force, it is only necessary to consider the direction of the primary current and whether it is increasing or decreasing in value. When increasing in value, it will induce an electromotive force that will oppose the flow of the current; when decreasing, the induced electromotive force will be in the same direction as the primary current and will therefore tend to keep the current flowing. If there is a secondary circuit, the voltage in it will be in the same direction as the primary current when the latter is decreasing in value and opposite to it when the primary current is increasing in value.

The preceding paragraph will be made clear by referring to Fig. 2. Assume that the primary coils *A* and *B* are connected to a source of alternating current and that the current wave is increasing in value in a direction through the coils, as indicated. Then the induced electromotive force in the secondary will be opposite to that in the primary; and if the secondary circuit is closed through a resistance *R*, a current will flow as indicated by the arrow-heads. When the primary current is decreasing in value, the action in the secondary coil will be reversed—namely, the secondary current will be flowing in the same direction as that in the primary coils.

Consider a primary winding on two separate polepieces *A* and *B* with a cylindrical core between them, having a secondary winding wound on the cylinder, as shown in Fig. 3. When the current is increasing in value in coils *A* and *B*, a current will be induced in the secondary coil *C* in the same direction as in Fig. 2. In Fig. 3, however, the secondary conductors under the polepieces will not have the same number of lines of force linking through them as those between the polepieces; consequently, the electromotive force induced in the turns under the polepieces will be less than in those between them.

Now it is only a short step to imagine both ends of the winding on the rotor cut off, leaving the conductors parallel with the core, as in Fig. 4. If these conductors are short-circuited by a ring at each end, as in Fig. 1, and an increasing current is sent through the field coils, a current will be induced in the rotor conductors in the same direction as in Fig. 3, which is toward the reader to the right of the vertical axis, and down through the plane of the paper to the left. The dots and crosses in the center of the conductors indicate the direction of the current.



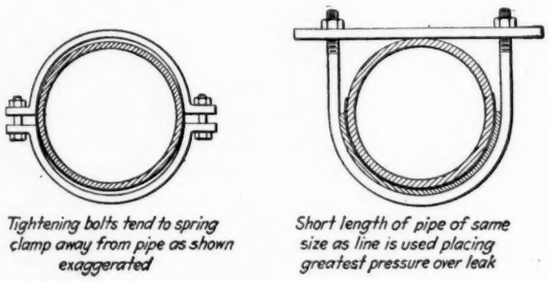
FIGS. 1 TO 4. CONVENTIONAL DIAGRAM DEVELOPMENT OF A SINGLE-PHASE INDUCTION MOTOR

In Fig. 1 the two conductors on the vertical axis are left blank, one on each side of the rotor. At the center of the polepieces no flux will be linking around these conductors, as this is the point where it divides, part going around to the left and part to the right. The electromotive force will therefore be zero in the center conductor, but will increase in value as the conductors

get farther away from this position, reaching a maximum value in those located on the horizontal axis. The reason for this is obvious, as the conductors located on the horizontal axis will have the total flux linking around them. Comparing Fig. 1 with Fig. 3, it will be seen that the current in Fig. 1 is distributed as it should be.

Pipe Repairing Kinks

In a 3½-mile pipe line recently laid for compressed-air transmission, there were found to be a number of places where holes had rusted through the pipe. Instead of using flat iron clamps bent to fit the pipe and bolted together, a short section of the same size of pipe split in half was clamped over the leak with U-bolts and bar-iron yokes, says *Coal Age*. The first type of


Tightening bolts tend to spring clamp away from pipe as shown exaggerated
Short length of pipe of same size as line is used placing greatest pressure over leak

TWO METHODS OF PATCHING SPLIT PIPE

patch, which is commonly used, tends to spring away from the leak when its bolts are tightened, while the latter puts the pressure right on the leak and makes a better and cheaper patch. Of course, with either style of clamp, gaskets are required. Tar paper or pasteboard from ordinary boxes gives just as good results, at least for several months, as the highest-priced gasket material.

Locating Grounds on Lead Sheathed Cables

By W. T. Roberts

Some years ago a 110-220-volt direct-current underground lighting system was installed, and after its completion the neutral cable was found to be dead grounded. The system was not permanently grounded, so it was necessary to locate the grounds.

The cables were 500,000 circ.mils, and as the system was intricate, the usual methods of locating faults could not be used. A diagram of the system is shown in Fig. 1. Only two cutout boxes were installed, at *M* and *M'*, and by opening these the ground was found to be in the loop; all other joints were wiped, and there was no way of isolating the different feeders for separate test. If a test had been made from the end of the cables at *M* and *M'*, the resistance of the cables would have been small compared with the contacts made at the instruments; therefore all usual methods were cast aside, and the following scheme was used with satisfactory results and without interfering with the service.

A current of 90 amp. was sent to ground at *A*, Fig. 1, through a resistance as shown in Fig. 2, the direction of the currents in the cable sheaths being determined by a millivoltmeter—that is, by taking the drop across a small portion of the sheath such as was available in the manholes *X*.

Two such millivoltmeters were used, the two men starting at *A* (Fig. 1) and going in opposite directions around the loop. Where the currents met in the sheath of the neutral, as shown by arrows, the ground was located. The nearer to the ground the readings were taken the larger the deflections, because the dissipated currents had to concentrate at this point before entering the neutral cable, which was grounded to the sheath.

A dead ground was located at *B*. Prior to locating this, the cable-insulation resistance to ground was zero. After the ground at *B* was removed and the insulation resistance

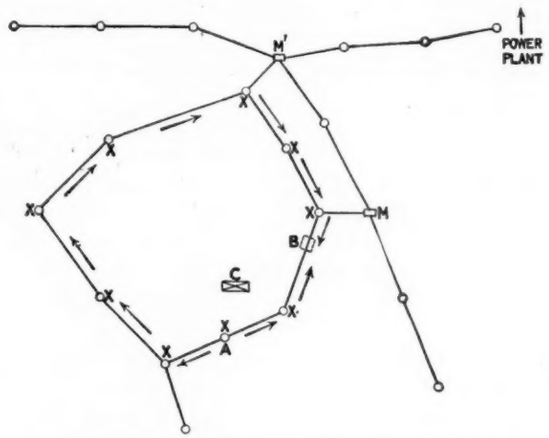


FIG. 1. DIAGRAM OF SYSTEM SHOWING DIRECTIONS OF TESTING CURRENT

measured it was found to be 0.83 ohm. It was surmised from this that another ground of low resistance existed at some other point. The test was continued the next day, and the second ground was found in a house at *C*. The neutral conductor was in direct contact with the metal ceiling, the ground then passing to the water pipes. After this was removed, the insulation resistance was found to have increased to 30 ohms.

Further tests by this method were considered impractical on account of the small current that would flow to

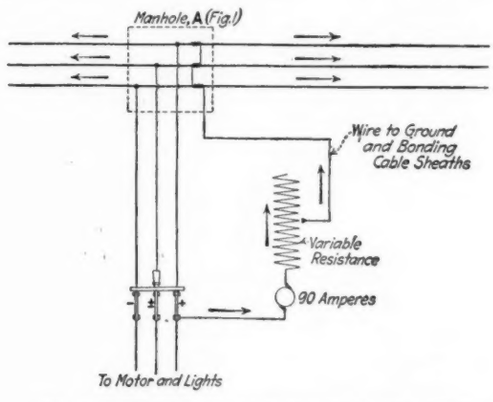


FIG. 2. SHOWING HOW TESTING CIRCUIT WAS CONNECTED

ground. Besides the cable sheaths, the whole water system carried part of the current; this of course limited the current carried to the sheath to a very small value, and the deflections of the millivoltmeter were about what was expected in this case, ranging from 2 to 80 divisions. The time spent in finding these faults was four hours.

Editorials

The Day of Big Things

When the engineer who has been operating a reciprocating power station assumes charge of a new turbine plant of the average size, he feels that he has risen quite a few degrees in the power-plant world. The output of the station may be less than a thousand kilowatts, but the exhilaration of the position is as much in evidence as if the units were larger.

A few years ago the operators of steam-turbine plants were the envy of the other engineers in the neighborhood, but today they are so common that it is at once assumed, in the instance of central-station service, that the equipment consists of steam turbines. These men are ready and for the most part capable of operating whatever apparatus may be put in their charge.

Almost weekly something is published about this, that and the other piece of power-plant apparatus being bigger, more powerful and of higher efficiency than anything heretofore produced. For instance, a turbine of twice the capacity of another occupies the same floor space and requires no more attention on the part of the operator.

Not so long ago a five hundred horsepower boiler was considered extremely large, but the size has been increasing year by year and at the present time units of twenty-four hundred horsepower capacity are being constructed and it is said that it is the intention to operate them at four thousand horsepower capacity.

Of any single company probably the Chicago Commonwealth-Edison Co. generates electricity on the largest scale—something like three hundred and forty thousand kilowatts; the two New York Edison stations' peak is about two hundred and forty thousand kilowatts. These steam plants are each of greater capacity than that of the Mississippi River Power Co., even when it reaches its ultimate volume of two hundred and seventy thousand kilovolt-amperes. One can scarcely realize what such capacities mean as regards the territory covered for lighting and power circuits.

A ten-thousand-kilowatt generator is not such a large machine when compared with some of the slow-speed generators of much less capacity, but they become dwarfed when compared with the largest generator now being built, of forty-seven thousand kilovolt-amperes. Still larger machines have been laid down.

Few engineers realize what the responsibility of operating such large plants and apparatus must be. The stopping of a forty-seven thousand kilovolt-ampere unit is serious and the cutting out of a twenty-four hundred horsepower boiler on a peak load would disturb the serenity of the most self-possessed engineer.

The builders of power-plant machinery are producing some of the largest apparatus the world has ever known, power plants are being operated at a higher pressure and greater capacity than ever before, and the men from the ranks are stepping in to do their part in making their operation a success in this day of big things.

Requests for Information

When we have endeavored to solve a problem that is of vital importance to us and have failed, it is very gratifying to have someone provide the solution. Usually the one supplying the information is pleased too, for to be asked for such assistance is always a compliment.

On the other hand there are questions that are pure impositions on the time and energy of any busy man. When a question is asked as to what may be gained by installing a new piece of apparatus, either as an adjunct to, or to take the place of, one that has probably outlived its usefulness, or how to make calculations relative to anything in your special field of endeavor—in fact, almost anything that is going to be of benefit to the questioner—it is a pleasure to give assistance. It is simply idle, however, to worry oneself or anyone else over such useless "post mortems" as the following: An electrical machine had been connected wrongly and certain bad effects were encountered after the apparatus was started, and when the mistake had been discovered and remedied and everything was going all right, the engineer wrote us to explain how he had the machine connected to get these effects. In the first place, if he had made a diagram before rectifying the connections, he could have answered his own question. In the second place, why be interested in wrong connections? No one whose time is valuable is; it is as much as he can do to study right methods.

It has been said, "Better ask foolish questions than none at all," but no editor will agree to that. It is always annoying to answer inquiries that have no practical value, no matter how much one delights in helping the other fellow where real information is needed.

Second-Hand Electric Machines

There is more truth than poetry in the statement that the nameplate on a second-hand electrical machine is not to be relied upon. It is not uncommon to find second-hand machines on which the nameplates have been changed by some unscrupulous dealer, in order to dispose of a piece of apparatus to an unsuspecting purchaser. This act, to say the least, is contemptible, as in many cases it is not the dealer who gets the blame when the machine does not meet requirements that from all outward indications it is intended for, but the manufacturer. Probably there is not an electrical manufacturing company that cannot recall having at some time been called upon to investigate trouble on one of its machines, only to find that the machine had been purchased second hand and that the nameplate indicated something foreign to that which the machine was designed for. This practice is all the more to be condemned, as in many cases, with no other expense than a few hours' work, the winding of the machine could have been changed to conform to what it was sold for, and there would have

been no need for changing the nameplate to deceive the purchaser. There are tricksters in every trade, and the second-hand machine business is no exception; it has its reliable and its unreliable dealers.

If the possibility of the nameplate being changed on the machine were the only element to be taken into account in buying second-hand machinery, its purchase might be justified in most cases. There are, however, the more important questions of efficiency and maintenance to be studied, or the result may be that the purchaser will pay interest on the capital saved, instead of having capital invested returning a good dividend. In a machine for continuous service 1 per cent. improvement in the efficiency will provide a big dividend on the difference in cost of a new machine and that of a second-hand one, not considering the additional expense of maintenance.

There are cases where comparatively modern machines can be secured second hand at a considerable saving, but frequently they have been discarded for more reliable and efficient equipment. If it is a good investment for the original owner to discard this apparatus and install the more efficient, it would seem to be advantageous to the one who contemplates buying second-hand machinery to abandon the idea and get new equipment. However, circumstances may render the purchase of old machinery justifiable, as in the case of machines for intermittent service, where reliability and efficiency are secondary and low cost is of primary importance.

The Evening Engineering School

The function of the evening engineering school is to continue the student's education from wherever his public-school attendance ended.

The success of any class depends chiefly upon the pupils—whether they get down to good hard study or whether they expect the instructor to grab handfuls of choice knowledge from the atmosphere and pass it around without requiring any effort on their part. If the latter is the attitude, the class is doomed to disappointment.

There is no doubt that one may become truly educated by diligent study and without the help of an instructor other than good books; but the way is long and uninviting, and one certainly not to be recommended to the normal man having "sure enough" red blood circulating within him. Man is a gregarious animal. He likes to "flock" with his kind—and labor seems lighter, pleasures greater and difficulties are sooner got over and forgotten when good fellows mingle together. Pat and Mike four miles from home were consoled by the thought that it was only two miles apiece—and probably it was in reality only about half as difficult a journey for two. The fellow who can "go it alone" and make a success would shorten the road for himself and help others along by the exercise of the same amount of effort in a class working along similar lines.

The benefits to be derived and those that are actually gained may differ extremely. One man may gather knowledge and be able to apply it both to the advantage of his employer and his own ultimate advancement, while another may miss the mark entirely. In this respect as we all know the evening class in no way differs from any other school. There are many well-tutored men who are unable to make use of their knowledge to any great extent. This, however, is not saying that schools are "all wrong," but it does suggest that the practical application of the principles taught is highly desirable, and this is afforded by the combined course.

One of the principal advantages of the evening school—a combination of practical work with a course of study—is that the obstacles encountered while at work act as a spur or incentive to study the cause of the difficulty and to make the student see the need of improving his capacity for reasoning; to realize more clearly just what he needs to know. The space at present devoted to such subjects in the technical press is significant. Robert J. Spence writes:

> Those who give the matter of evening trade schools a thought must view them as places of inspiration and advancement for the ambitious. A person who has the energy and ambition to rush home at the close of a hard day's work, gulp his evening meal and hurry to the school must have some, if not all, the qualifications that go toward success and is therefore deserving of it.
>
> It is for the ambitious that the evening trade school is maintained and its underlying principles coincide with the ideals of good citizenship. It gives the pupils a supplementary training in the evening that will aid them in taking the next step forward in their daily work.
>
> Men in factories are not hired with any idea of helping them to advance by trade training, but for their immediate power of productiveness. Assisting the worthy to a better development in knowledge, it is not the intent to get any financial return to the city or organization for its investment, but so to better the training of workmen that their added wage and intelligence will count toward civic betterment.

In a recent discussion in a technical journal, Prof. George F. Swain favored a combination of practical work with the study of the theoretical principles, and stated in part somewhat as follows: "A large proportion of the students in our colleges and engineering schools would better themselves if, instead of going to college they went to work and earned their own living. They would be more benefited by a training in the University of Hard Knocks. A young man who goes to work instead of to college, and who learns in his work what he needs to know in order to rise above his fellows, and supplies this need by correspondence or night courses will be apt to acquire more real knowledge than the average college graduate." Concerning the wisdom of continuing schools, although not 100 per cent. efficient, he says, "No one would argue that because an electric plant delivers in current but a small portion of the energy in the coal it should be shut down. The thing it does accomplish is so highly valuable."

The evening class may not be any more efficient than the steam engine, but it is a mighty good machine at that. Ralph Waldo Emerson says, in effect, that any man with an ordinary brain can make good, if he has the willingness to run that brain up to, say, eighty per cent. of its highest efficiency.

"If you concentrate, you will be accurate; if you are accurate, you will be efficient; and if you are efficient, you will be successful."

When the steam turbine was so rapidly coming into its own, some folks got the idea that this prime mover would sweep the reciprocating engine into oblivion. This has not happened, yet turbine builders have found open to them a field vaster than they dared at first to imagine. They are reconciled to the engine and appreciate that both it and the turbine have fields of their own. There is every reason to expect that the central station-isolated plant competition will work out in the same way.

Correspondence

Rope Drive Versus Belt Drive

In the issue of June 20, page 887, C. S. Reeves asks the authority for the statement that a belt drive has a higher efficiency than a rope drive under any conditions. The following, clipped from *Machinery* about eight years ago, describes some experiments performed at the Technical Institute at Charlottenburg, Germany, in which the belt has just a shade the better of the rope—1 per cent.

The highest efficiency obtained during the tests referred to was 98 per cent. with the belt drive, and by a single rope 97 per cent.; using two ropes side by side, 95 per cent.; with four ropes side by side, 90 per cent., the friction losses in the bearings being subtracted. The efficiency in the case of rope drives thus decreases about in proportion to the number of ropes employed.

Lionel S. Marks' Mechanical Engineers' Handbook gives the following range of efficiencies for rope drives with one to eight ropes: American system, open drive, 91 to 94 per cent.; American system, "up and over" drive, 58 to 81 per cent.; English system, open drive, 73 to 86 per cent.; English system, "up and over" drive, 56 to 77 per cent. Belting efficiency is given as 96 to 98 per cent.

It would be possible, no doubt, to rig up a rope and belt drive side by side and so arrange them that the former would be the more efficient, but I am convinced that where conditions are made ideal for each, the belt drive will show the higher efficiency. S. F. WILSON.

New York City.

Action of Furnace Gases

In his interesting article, "Action of Furnace Gases," in *Power* of April 25, S. H. Viall makes the following statement: "The writer knows of a stoker-fired plant containing 400-hp. boilers in which the CO_2 at the dampers averaged 9½ per cent. with no CO. Investigation showed about 13½ per cent. CO_2 at the end of the flame travel. The boiler settings were worked upon until 13 per cent. CO_2 was obtained at the dampers with the same furnace conditions. The efficiency was not yet satisfactory. Experimental tests were then made which showed that 10½ to 11 per cent. CO_2 gave the best returns. Low-grade Iowa coal was used. The efficiency was about 65 per cent. and was between 3 and 4 points higher than previously obtained with 13 per cent. CO_2 and no CO."

This statement is incomplete, as it does not give the temperature of the flue gas on leaving the boiler; the heat loss up the chimney can therefore not be ascertained from the figures given. With a given fuel, however, burned at the same rate of combustion and under the same boiler and furnace conditions, the stack temperature becomes less as the percentage of CO_2 increases. The weight of the flue gas also decreases as the percentage of CO_2 increases, and since the heat loss is the product of the weight, temperature and specific heat of the escaping gas, the heat loss up the chimney must necessarily be greater as the percentage of CO_2 becomes less, provided combustion is complete.

The heat carried up the chimney by the day flue gas may be determined with a close degree of approximation by the formula

$$\left(0.24 + \frac{58.46}{P}\right) \times (T - t) = \textit{loss in B.t.u. per lb. of carbon burned to } CO_2$$

in which

P = Percentage of CO_2;
T = Temperature of gases leaving boiler;
t = Temperature of the boiler room.

Since the temperatures T and t are not given, only the gas factors $0.24 + \frac{58.46}{P}$ can be compared. Substituting the average values of P presented by Mr. Viall gives

$$0.24 + \frac{58.46}{10.75} = 5.68$$

$$0.24 + \frac{58.46}{13} = 4.73$$

$$\frac{(5.68 - 4.73) \times 100}{4.73} = 20 \textit{ per cent.}$$

difference in the value of the two heat waste factors in favor of the higher percentage of CO_2.

Assuming the stack temperature to have been 550 deg. and the boiler room 75 deg. for both CO_2 percentages (it should be lower with the higher CO_2), there is a greater heat loss with the lower percentage of CO_2 of

$$\left(0.24 + \frac{58.46}{10.75}\right) \times 475 - \left(0.24 - \frac{58.46}{13}\right) \times 475 = 451 \textit{ B.t.u.}$$

Therefore if, as Mr. Viall states, combustion was complete, there being no CO accompanying the higher percentage of CO_2, there would be 451 more B.t.u. available for the boiler with the higher percentage of CO_2, provided all other conditions are the same. If the boiler did not respond to this greater amount of heat available because of the higher percentage of CO_2, something was wrong. Either the supposed complete combustion did not take place and the heat saved from going up the chimney was overbalanced by the heat value of combustibles carried off by the gas, or the assumed sameness in stack temperature did not exist, but because of dirty heating surface or a higher rate of driving, the temperature of the escaping gas was enough higher with the higher percentage of CO_2 for more heat to be carried off by the lesser weight of gas than by the greater. Whatever the cause of the lower boiler efficiency with the higher percentage of CO_2, it cannot be charged legitimately to the latter, when complete combustion ensues.

Maximum boiler efficiency can result only when maximum combustion efficiency is maintained. Maximum combustion efficiency means the complete burning of a fuel with the minimum excess of air, or what is the same thing, a maximum percentage of CO_2 in the products

of combustion. This does not imply, however, that the products of combustion resulting from the highest obtainable combustion efficiency must contain a definitely fixed percentage of CO_2. The highest percentage of CO_2 obtainable depends, first, on the kind and condition of the fuel burned, second, on the construction of the furnace, and, third, on the manner of stoking.

The first is controlled by the location of the plant and commercial reasons, the second by engineering ability and experience, and the third by the skill and attention of the fireman.

But whatever the conditions as to kind of fuel and construction of furnace, to get the best results the fireman must strive to get the highest percentage of CO_2 compatible with complete combustion. To succeed in this he must be provided with a convenient means for regulating his damper, for observing and analyzing his draft and a CO_2 indicator at the boiler front, so that he can see at all times whether his adjustments are right. Without these aids, he is working in the dark and cannot be expected to attain and maintain maximum combustion efficiency, regardless of the fuel or furnace conditions.

Passaic, N. J. E. A. UEHLING.

Use of 220-Volt Motors on 110-Volt Circuit

There are several points in H. L. Hervey's criticism on page 889 of the June 20 issue on the question "How would the speed and power of a 220-volt motor be affected if used on a 110-volt circuit?" which I do not agree with. His statement with reference to testing a 220-volt motor on 110 volts without making any changes in the windings that "when the motor is unloaded the speed will be almost correct as for the 220 volts, but when a load is applied the speed falls rapidly" is not correct in either theory or practice. Having the opportunity I took the speed of two motors running under the conditions mentioned. A 5-hp. 230-volt Sprague shunt machine ran 1,140 r.p.m. on a 230-volt circuit; when connected on 115 volts, it ran 775 r.p.m., a decrease of about 32 per cent. A 10-hp. 230-volt G. E. shunt machine ran 1,410 r.p.m. when connected on a 230-volt circuit and 895 r.p.m. when connected on 115 volts, a decrease of about 36.5 per cent. This does not look much like running at the same speed when unloaded on either voltage. As to the speed dropping off rapidly when the load is applied when the machine is operating on 110 volts, this is also an error. The speed variation will not be much different when the machine is operating on 110 volts than when on 220 volts. In taking the speed of the 5-hp. Sprague, it was found to drop from 1,140 r.p.m. at no load to 1,043 r.p.m. at full load when operating on 230 volts, a decrease of 97 r.p.m. On 115 volts the speed dropped from 775 r.p.m. at no load to 719 r.p.m. at full load, a decrease of only 56 r.p.m., which indicates the opposite of Mr. Hervey's statement. The full-load current of this machine in either case was 19 amp.

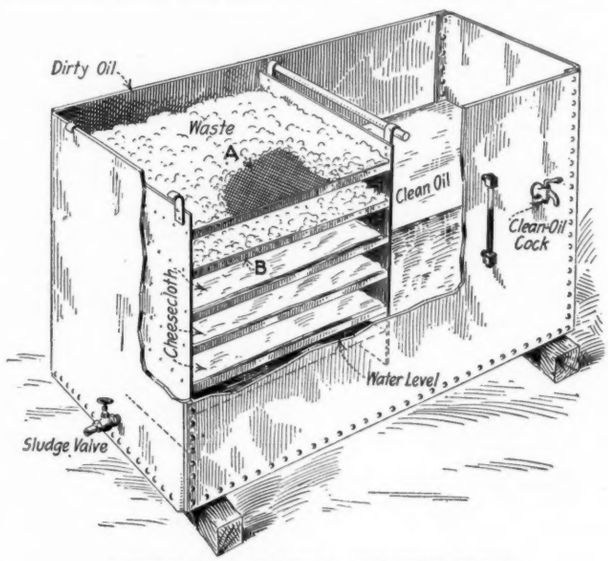
If the field coils are divided into two equal circuits and paralleled, which Mr. Hervey states is the proper thing to do, the machine is no longer a 220-volt motor, but a 110-volt machine of one-half the horsepower rating, running at one-half the speed of the 220-volt machine, and is therefore outside this question. It is not always possible to divide the field winding and parallel it without rewinding, at least, one-half of the winding, as there are on the market makes of machines that have but one field coil in them. Furthermore, if a 220-volt motor of given horsepower and speed is required to drive a certain piece of apparatus, I fail to see where a 110-volt machine of one-half the horsepower rating and speed would be satisfactory.

On the other hand, unless the name-plate is restamped, a 220-volt machine changed to work on 110 volts is a violation of the National Board of Fire Underwriters' Code. Rule No. 8, Sec. h, states: "Must each be provided with a name-plate giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute. B. A. BRIGGS.

Washington, D. C.

Homemade Oil Filter

The accompanying sketch shows an oil filter that I made for our plant, as we were badly in need of a filter and unfortunately the company did not feel disposed to buy one. In the storeroom was found an old 54x40x18-in. steel tank that had been used as a boiler-compound tank. From the local junkyard I secured several strips of steel



DETAILS OF FILTER CONSTRUCTION

about ¾ in. wide by $\frac{3}{16}$ in. thick, also two pieces of 18-gage iron 17⅞ in. wide by about 22 in. long. The narrow strips were bent to form rectangles 17½x27 in. Five of these were covered with heavy screen as at *A* and spaced equally in one end of the filter, as shown at *B*. They were riveted to sheet-iron pieces to which hooks were riveted at the top. A rod was run through the tank to hold one side of the basket, the other side being hooked to the end of the tank. A gage-glass and clean-oil cock were fitted in the positions shown. An old 1-in. pipe connection and valve in the bottom at one end of the tank served as a sludge and drain valve.

The action of the filter is as follows: the two upper shelves of the basket are filled with waste to a depth of about 3 in. The three lower shelves are covered with five or six layers of cheesecloth. The tank is then filled with water up to the point indicated, and the filter is ready for use as soon as the basket is placed in position.

The oil to be filtered is poured into the top of the basket and passes down through the waste and cheesecloth through the water and rises in the clean-oil chamber. From here it is drawn off through the clean-oil cock. This device thoroughly filters the oil, and the actual cost was about $2.

The basket may be removed at any time to renew the cheesecloth and waste; the water should be drawn off frequently and replaced by clean. A steam coil could easily be placed in the filter to keep the oil and water warm if it was necessary to put it in a cold place.

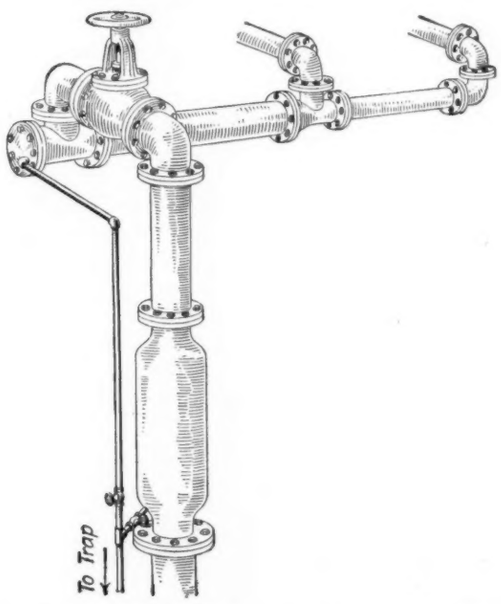
Hume, N. Y. CHARLES RYAN.

Draining Steam Lines

In laying out piping plans for power plants, I believe engineers are placing entirely too much dependence on traps.

The illustration shows the piping layout for a small municipal plant as designed by a firm of reputable engineers. The header is drained through a ¾-in. line, which also drains the separator and is connected to a trap below the floor. If the header drain valve should be closed or the trap should fail to work, water would gradually enter the 6-in. header and by a sudden rush of steam would be picked up and carried over into the engine unless the separator was unusually large.

A sediment chamber in the line, drained to the trap, will eliminate the danger if kept clean by being blown



ONE TRAP EXPECTED TO DRAIN TWO POINTS

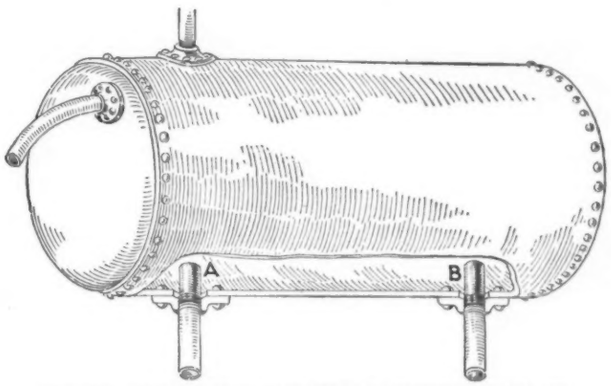
out once in awhile. Few engineers insist on having sediment traps, and few realize that the diameter of the opening from the average so-called ¾-in. steam trap is only about ¼ in., or $\frac{5}{16}$ at most.

Steam traps are generally placed where they are not easily accessible and given very little attention, although their function is important. They should be inspected and overhauled just as regularly and perhaps a little more often than any other appliance in the plant, and certainly more frequently than they usually are in the average plant. HOWARD G. SCHULER.

Kansas City, Mo.

Improved Tank Connection

Apartment houses as a rule are poorly equipped for supplying hot water for general use. In this particular one a cast-iron heater is connected to a steel tank or range boiler from which the whole building is supplied, and it is often necessary to run the fire slowly during



CIRCULATING PIPES EXTENDED INSIDE OF TANK

the night in order to have the water in the tank and house lines heated to 180 to 200 deg. early in the morning, otherwise the heater is not able to do the work during the day. When the water in the tank got good and hot it was always dirty and unfit to use, but to put in a filter was out of the question as the owner would not go to that extra expense; so it was quite a problem how to overcome the difficulty.

The circulating line *A* and return line *B*, shown in the illustration, were tapped into cast-iron flanges riveted to the shell, so that the sediment in the bottom of the tank would not be stirred up and carried up into the house.

By putting two 2-in. nipples about 4 in. long inside the tank—practically extending the pipes up inside the tank—the bottom was turned into a mud drum containing cold water where there was no circulation, and consequently no dirt would be stirred up, when once settled down there. The capacity of the tank is reduced a little, but the water is clear. LUDWIG MEYER.

New York City.

No Ports in Pump Cylinder

A marine-type condenser air pump having a beam with a vertical steam cylinder working on each side of the fulcrum and the water cylinders connected to the same beam at the ends, operated on a vessel for four years before it was finally discovered that the steam ports in one of the cylinders had never been cleared.

That this could happen and remain undiscovered so long was due to the type of construction and the conditions of operation, in which it was possible for one cylinder to do all the work with high-pressure steam and drag the dead cylinder by means of the beam. The exhaust steam entering the dead cylinder kept it hot and so deceived the erector and the engineers. There had been considerable trouble, however, with the lubrication of the cylinder, which was a puzzle, but when the ship was put into a new service and the engines speeded up, conditions grew acute, and the cause of the trouble was discovered when it was found that no live steam could

be blown through a lubricator pipe tapped into this cylinder.

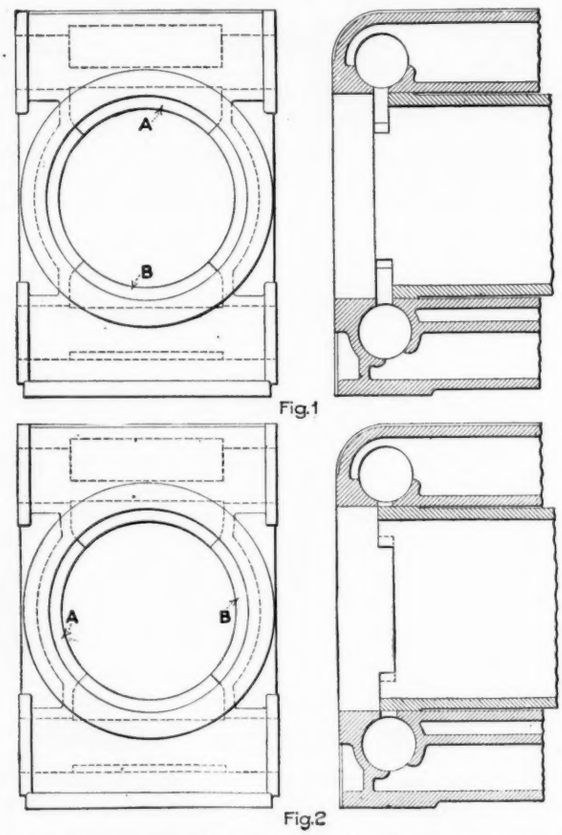
Reasoning backward from the cause, it was then easy to understand the peculiar conduct of the pump; incidentally, the lubricators were taken off entirely after the new cylinder head—with ports—was put on.

New York City. H. E. HOFFSTADT.

Why Engine Would Not Run

Several years after a cross-compound noncondensing Corliss engine was installed in a factory, it was decided to operate condensing in order to obtain better economy. To do this it was necessary to change the cylinders to the proper ratio for condensing purposes, and this was accomplished by bushing the high-pressure cylinder.

The bushing was made and pressed in place with $\frac{1}{32}$-in. clearance between it and the cylinder head at each end, to insure a tight joint between the cylinder and the heads.



FIGS. 1 AND 2. POSITION OF BUSHING BEFORE AND AFTER TURNING IN THE CYLINDER

The ends of the bushing were cut away for steam and exhaust ports, as shown at *A* and *B*, Fig. 1.

After bushing the cylinder, the engine ran satisfactorily for about a month and then would not pull the load except at a much later cutoff than when first started. The indicator diagrams showed evidence of much choking and wiredrawing in the high-pressure cylinder, and it was surmised that the valves required adjusting.

The back bonnets were removed, and the markings showed that the valves were properly set. The engine was again started without the cause of the trouble being discovered. Finally the engine would not pull the load at all; in fact, would barely run under no-load conditions.

A more thorough examination was made, and it was found that the bushing had become loose and had gradually worked around the cylinder until the recesses *A* and *B* were almost in a horizontal position and the projections between them almost closed the steam and exhaust passages, as shown in Fig. 2.

A new bush was put in and properly secured, and no further trouble resulted. C. A. MERTON.

Chicago, Ill.

Priming-Prevention Kinks

The illustrations show home-made devices used to prevent priming. None of them have been used by me. The

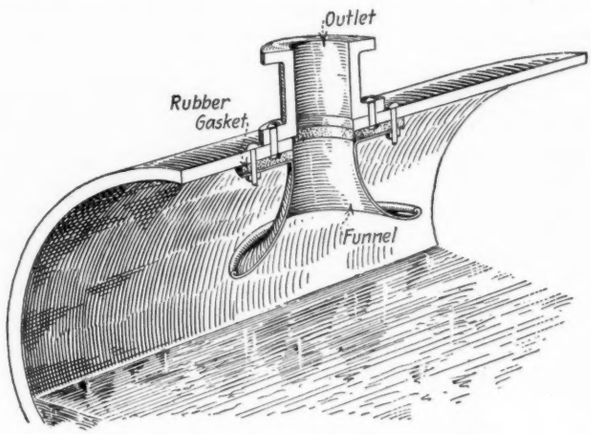


FIG. 1. FUNNEL ON OUTLET; A POOR PRIMING PREVENTIVE

engineers that designed them said they worked satisfactorily.

Fig. 1 shows a heavy galvanized sheet-iron funnel arrangement bolted to the top of the boiler shell at the steam outlet. The users' claim is that when a large quantity of steam is being drawn from the boiler, the

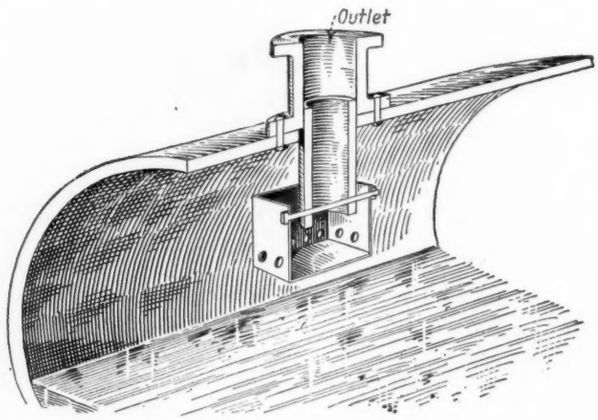


FIG. 2. BOX WITH PERFORATIONS AT BOTTOM

water has a tendency to flow toward the outlet, following the side of the shell. The funnel acts as a baffle separator, tending to throw the water back away from the outlet.

Fig. 2 shows a box, open at the top with the end of the outlet extended down into it. According to the inventor's confession he nearly succeeded in causing a wreck, as the box filled with water during a shutdown and the water came over into the engine when the valve

was opened. He drilled a number of holes near the bottom of the box, as shown, and had no further trouble; in fact, he claimed that the boiler could not be made to prime. Probably reducing the outlet from 3 in. to 2½ in. had

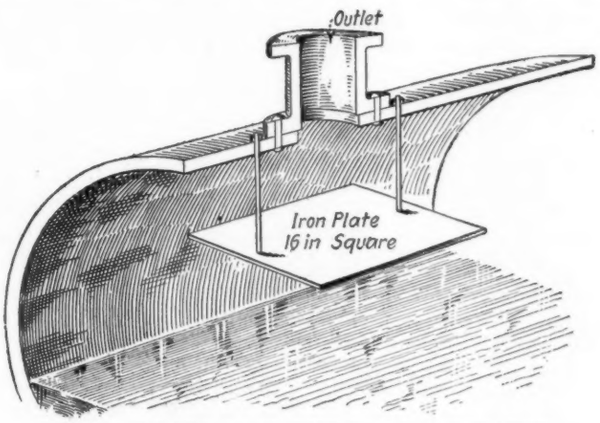


FIG. 3. PLATE TO THROW BACK THE WATER

something to do with his success. Another baffle for which success was claimed is shown in Fig. 3. The inventor of the device shown in Fig. 4 tried to get away from commonplace ideas. Inside the boiler he built a 2x3-ft. screen, of thin strips of galvanized iron and wood and suspended it by two brass chains so that at ordinary

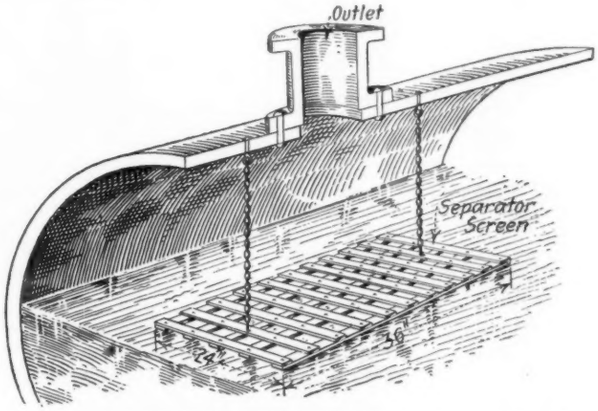


FIG. 4. FLOATING SCREEN BELOW STEAM OUTLET

water level the screen would float on top of the water; if the water got a little high the screen would rise with it. How long he expected it to float he did not state. His idea was that the screen would retard the water, allowing it to fall away from the steam.

Asked if the separator would not prove more effective if suspended above high-water level, he stated that he had tried it, but with no satisfactory results.

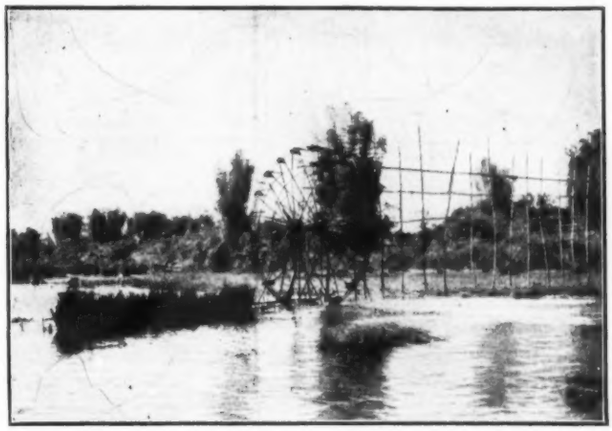
Toronto, Ont. JAMES E. NOBLE.

A Bamboo Waterwheel

Throughout the Philippines, on such islands as Panay, Luzon and Cebu, bamboo waterwheels are in use for irrigation work, rendering a service that speaks well for the ingenuity of the natives in devising a mechanism of practical utility, correct both in the principles of construction and in operation.

The accompanying illustration, reproduced through the courtesy of I. W. Swaren, shows a typical Philippine bamboo waterwheel. The wheel, shaft and appurtenances are bamboo; it has a diameter of about 12 ft., with paddles 24 in. wide, formed of split bamboo into a rather coarsely woven texture. The bearings, or supports, are two bamboo sticks crossed, the lower ends of which are driven deep into the mud of the river bottom to form a suitable foundation. The hubs of the wheel comprise a lashing to hold the slender spokes in place.

This waterwheel is used to lift the water above the level of the river and has buckets made of single-joint bamboo. These buckets, fastened to the periphery, hoist



PHILIPPINE BAMBOO WATERWHEEL

the water to the top of the wheel and then empty it into a flume constructed of the split trunks of bamboo trees; this flume is supported by a series of bamboo uprights. The wheel operates at a maximum speed of about 4 r.p.m., lifting about 20 gal. of water into the flume in this time. During a 24-hr. period an average total of from 25,000 to 30,000 gal. of water is delivered. The shrub growth in the river, adjacent to the wheel, shown in the illustration, is a dam formed of grass and bamboo to increase the available head. L. R. W. ALLISON.

Newark, N. J.

Effects of Shifting Eccentrics

An Allis-Chalmers Corliss engine was tested to determine what effect changes of angular advance of the eccentric would have upon the horsepower and steam consumption. The engine had an 8x24-in. cylinder and was rated at 25 hp. The steam pressure was kept constant at 70 lb. throughout the test. The results are shown in the accompanying illustrations.

In starting the test the valves were set as nearly correct as possible, the engine was brought up to a speed of 100 r.p.m., and a brake load of 200 lb. was put on the flywheel by an ordinary prony brake, the radius of the arm being 4 ft. 3 in. The diagrams *A*, Fig. 1, were then taken, the "H" and "C" denoting the head and crank ends. The engine was then stopped, and the eccentric was loosened and turned backward 3 deg.; or in other words, the angular advance was decreased 3 deg. The engine was again brought up to speed, and with the same load of 200 lb. on the brake, diagrams *B* were taken.

In the same manner the diagrams *C* were taken. Those at *D* were obtained after the angular advance had been reduced another 3 deg. After decreasing the angular advance another 3 deg., diagrams *E* were taken.

Another set of cards was obtained by again setting the angular advance normally and gradually increasing it 3 deg. at a time. The general results were the same as the first ones—that is, the power developed gradually increased—and the cards became more and more "freakish" in appearance, as can be seen from Fig. 2.

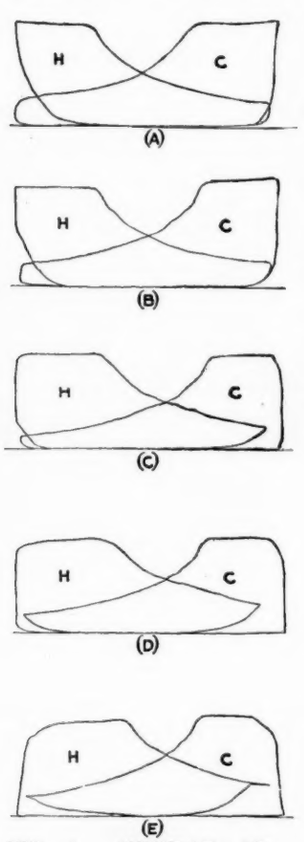


FIG. 1. ANGULAR ADVANCE DECREASED

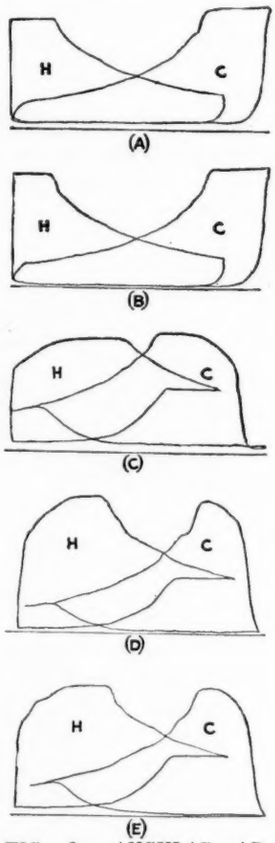


FIG. 2. ANGULAR ADVANCE INCREASED

Upon investigating the cards and the data attached, it is seen that the engine developed more power during the time that the "freakish" cards were taken than it did at first while the more normal ones were obtained; and the first thought that suggests itself is, Why not set the valves so that the indicator cards like D, E, Fig. 2?

If the cards in the "freakish" sets show the same horsepower as those in the normal sets and the steam consumption remained constant, it would make little difference within wide limits what angular advance was given an engine, but further tests bring out the fact that the steam consumption increased very rapidly while the power developed remained practically constant.

The steam consumption during the time that the angular advance was normal was 22.15 lb. per i.hp.-hr., while during the time the setting was varied the most, as shown by the "freakish" cards, the consumption was 43.2 lb. per i.hp.-hr., or nearly twice the amount used when the angular advance was set normally, thus showing the importance of giving the valve the proper setting.

Ithaca, N. Y. F. G. BAENDER.

Turbines Can Be Designed to operate on very low terminal pressures with comparatively slight increase of cost; their action as heat machines is such that a greater expansion can be utilized and the economy is greatly improved by any increase in vacuum. When run noncondensing, the turbine is less economical than the noncondensing engine.

Water-Column Connecting Pipes

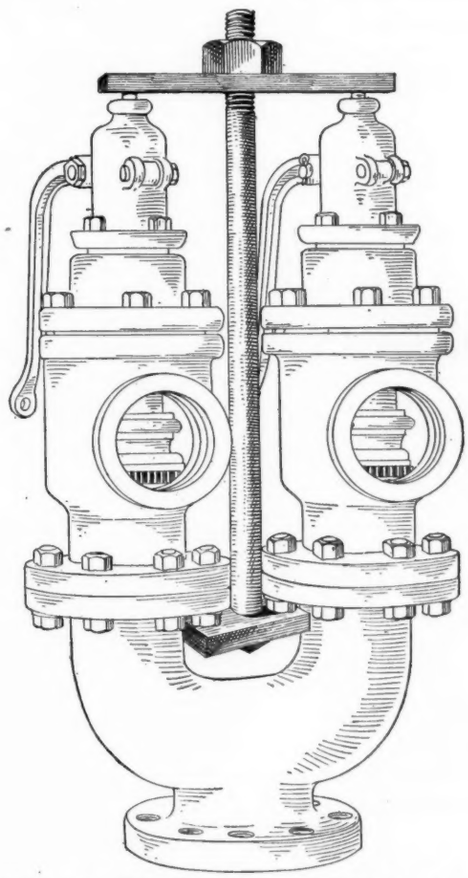
Considerable has been written about the corrosion of pipe connections to water columns. Why not insist that brass pipe and fittings be used? Such pipes, installed 18 years ago to my knowledge, are still in use and in good condition.

The bottom connection should have a plugged tee or cross instead of an elbow, to allow cleaning scale or any obstruction out of the pipe, but unless the water is unusually bad the top pipe does not need a cleanout plug. I am among those who believe that there should be straight-way valves in all water-column connecting pipes and that unions instead of right-and-left couplings are far preferable for column connections; for after they are on some years, it requires much less pulling and twisting to remove the unions. J. E. NOBLE.

Toronto, Ont., Canada.

Holds Pop Valve Down

A simple device is here shown for use in the hydrostatic test of steam boilers. It is designed for holding pop



BOLT FOR HOLDING DOWN SAFETY VALVES DURING HYDROSTATIC PRESSURE TEST

safety valves upon their seats while pressure is raised for testing purposes above the point of blowing.

Philadelphia, Penn. EDWARD T. BINNS.

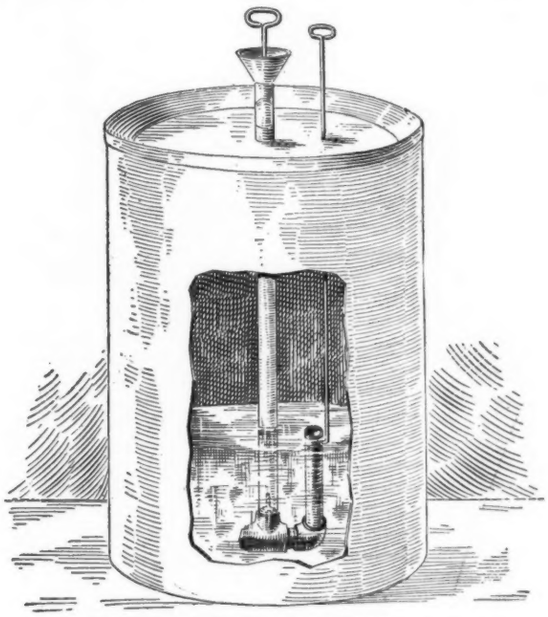
An Engine Runs Forward or Over when, standing at the cylinder and looking toward the flywheel, the wheel revolves in a direction away from you.

Low Oil Level Indicator

It frequently takes some time to put requisitions through our purchasing office and have the goods delivered, and we were often inconvenienced because the men in charge failed to notice that the supply of oil in the storage tanks was getting low before the tank was actually empty.

To overcome this we attached loosely to the suction of the oil pumps in each tank a pipe, as shown in the illustration, turning vertically about 14 in.

After the tank has been filled, the end of the suction pipe is turned upward so that, instead of taking oil



HIGH-LEVEL PUMP SUCTION PIPE

from the bottom, it is drawn from a higher level. When the oil reaches this level, the suction is lost and the attendants are warned that it is time to requisition more oil. To take care of requirements in the interval, it is only necessary to turn down the vertical pipe to the lowest level in the tank. M. SALLER.

Philadelphia, Penn.

Both the Exciters Had Reversed Polarity

We had just installed a 225-hp. Diesel engine directly connected to a 160-kw. alternating-current generator, as auxiliary to two water-driven generators of the same size and make as that connected to the Diesel. Each had its own exciter, belt-driven, and all were arranged to be run in parallel on the same exciter bus. Voltage regulation was by a Tirrill regulator.

We had started the Diesel unit to try it and, after running awhile without load, prepared to put on load by building up the exciter voltages equal to that on one of the water-driven exciters; then closed the exciter switch and cut in the regulator. Things began to happen right away, with the load shifting from one exciter to the other, and it was all I could do to handle the equalizing rheostat fast enough. We decided to cut out the exciter, but before the switch could be pulled there was a screeching of first one belt and then the other, and after the exciter switch was out, on looking things over, it was found that the water-driven exciter had motored and its polarity had been reversed; but as the excitation on the alternating-current generator was all right, we let it run until the load was light, and there was therefore no interruption of service.

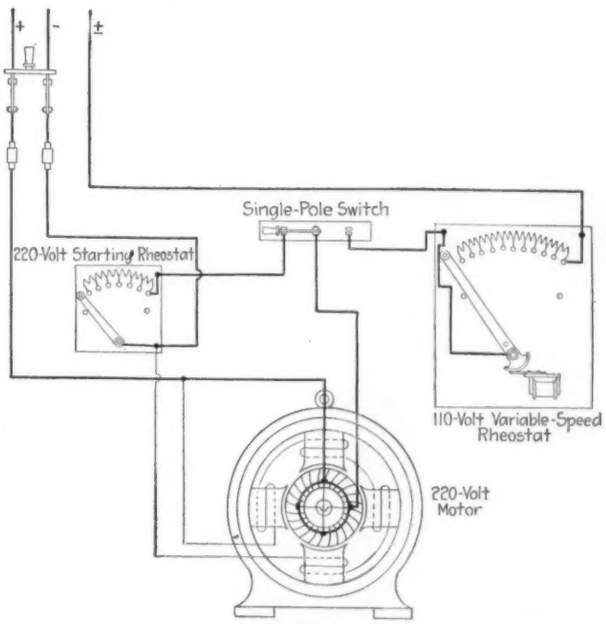
The Diesel was still running, and on attempting to build up the voltage on that exciter again, it was found that its polarity was also reversed. Both had motored in turn and had their polarities reversed. This was probably caused by slipping of the belts.

As soon as the load was light, we started up the second water-driven unit and shut down the other. We had supposed that the exciters were all flat compounded, as they were all of the same make, but found that the new exciter was considerably overcompounded and that was what caused the trouble. GROVER SYKES.

Rice Lake, Wis.

Boiler Pump Motor Control

The sketch gives the arrangement used with a motor for operation on either 110- or 220-volt circuits. This motor does double duty when the heating plant is in operation. Ordinarily it drives the boiler-feed pump, but the belt is at times shifted to drive a submerged centrifugal pump for emptying the sump. When performing the latter



MOTOR CONNECTIONS FOR EITHER 110 OR 220 VOLTS

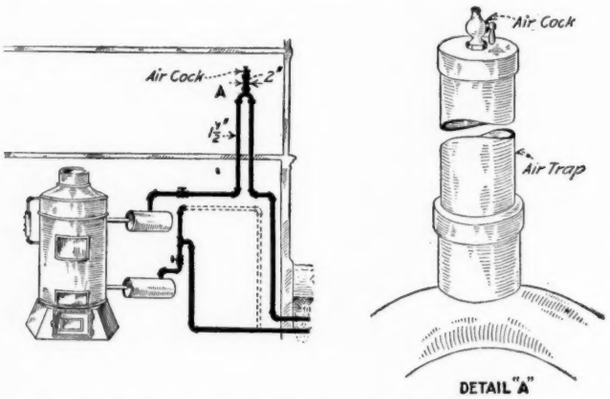
service, the motor operates on 220 volts. This voltage is also used if it is necessary to crowd the boiler-feed pump. For the usual boiler-feed service 110 volts is used. The rate of pumping is varied by using the rheostat shown.

The single-pole double-throw switch is used to change the armature voltage. When this is at the left, the 220-volt starting rheostat is used and the motor runs at its rated speed. When it is thrown to the right, the variable-speed 110-volt rheostat is in service. This control is simple and easily handled. In this case electric drive was used because the boilers carry low pressure, generally less than ten pounds. C. V. HULL.

Charles City, Iowa.

Hot-Water Heating Suggestion

Referring to the issue of May 16, page 709—Arthur D. Palmer's letter—an improvement can be made in the plan shown, by using a "back outlet return bend" instead of the return bend shown at the top of the loop, because no automatic valve is absolutely reliable for hot water, as lime or other deposits will cause the seat to adhere to



AIR OR VACUUM CHAMBER ON PIPE LINE

the disk and prevent its opening. Therefore an extension such as shown at *A* is used as an air reservoir so that the system will continue to operate even with considerable air, but if the bend alone is used and the air-cock is not opened, the circulation will stop with a small amount of air.

There will be no difference in the operation of the system whether the mains are laid level or with a fall in either direction so long as all pockets are tapped, but this is done more readily if there is a slight rise in both feed and return pipes from the lower elbows at the boiler end to some high point.

Considerable sediment is likely to collect in time in the underground pipes, affecting the circulation. As good a way as any to remove this deposit is to disconnect the mains and flush them out with a flow of water under pressure. This sediment is always soft if the system is kept full of water, and it will therefore wash out easily at any time. JAMES E. NOBLE.

Toronto, Ont., Canada.

Automatic Stop Valve Leaked

When starting to clean a 550-hp. water-tube boiler, about an inch of water was found in the drums. It was drained out, but after a few days reappeared, and it was noticed that 1½ in. of water accumulated every 24 hr.

The nonreturn stop valve was removed and found to have a groove ½ in. wide above and through the threads between the valve proper and the seat. There were also a few smaller grooves, all of which are probably sand holes. Steam at 150 lb. from the header had condensed and found its way into the boiler through these new channels. The chief engineer ordered the grooves filled with a cement until a new valve body is obtained. The boiler has been cut in and out again and no leakage appears.

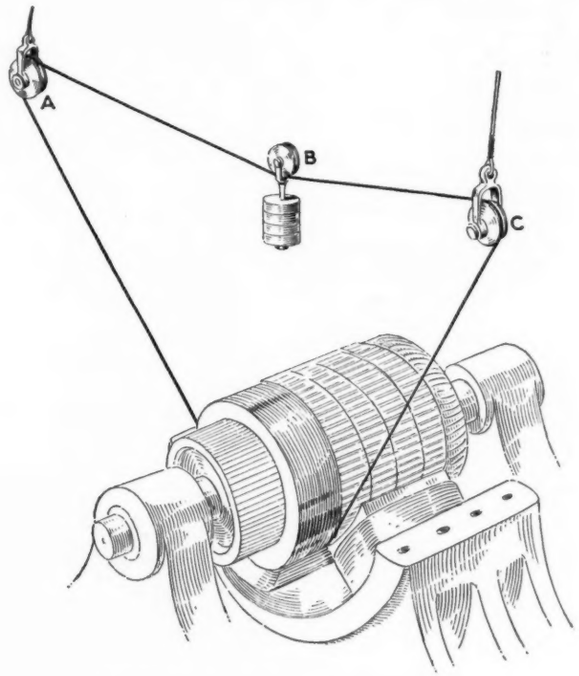
We find it good practice to clean these valves thoroughly, especially the piston, to prevent it from sticking in the dashpot. W. T. OSBORN.

Newark, N. J.

Replacing Band Wires

In rebanding armatures a method that I have used and found satisfactory for years upon all types of machines having a two-piece field yoke is as follows:

Remove the top half of the field yoke and determine the number of wires to be used in the bands. Then secure the end of the wire to the armature and wind the



METHOD OF KEEPING WIRE TAUT

desired number of turns plus two upon a part of the armature rod to be rebanded. Having done this, pass the free end of the wire through the pulleys *A*, *B* and *C* as in the sketch, then back to the armature and secure this end after having drawn the wire taut by hand. Give the armature one turn, then add enough weights on pulley *B* to pull the wire taut. It is obvious that the wire will now wind upon the armature as a band as rapidly as it is being unwound, and the result is accomplished without removing the armature from the machine.

When nearing the last turn of the band, it is advisable to remove part of the weight from *B;* otherwise one portion of the band will be taut while the other is loose. When the full number of turns is in the band, the band clip may be bent over on the wire and soldered. The weights are then removed from the pulley *B* and the ends of the wire are neatly trimmed at the band clip. Having done this, the band is ready to be soldered. The wire should be well sand-papered before winding on the armature as a band.

For a soldering fluid I have found the following to give the best results for band wires: Saturated solution of zinc chloride, five parts; alcohol, four parts; glycerin, one part. V. W. MILLER.

Hartford, Conn.

Removing Pulleys that have been rusted on shafts is frequently a troublesome job, but can generally be accomplished by heating the hub with a charcoal fire or some other means. The hub will expand, and the wheel can be easily removed. Care should be taken, however, not to heat the shaft, for if it expands as much as the hub nothing is gained.

Inquiries of General Interest

Largest Transformer—What is the largest size of transformer that has been built? B. A. S.

Probably the largest transformers in capacity rating, so far constructed, are two 60-cycle three-phase 14,000-kv.-a. units installed at Shawinigan Falls, Que., Canada. These transformers step up from 6,600 volts to 100,000 volts.

Most Efficient Steam-Turbine Velocity—For maximum theoretical efficiency of a steam turbine, what must be the relation between the speed of the buckets and the velocity of the steam at entrance? J. J. H.

The efficiency would be highest when the velocity of the buckets is one-half that of the steam at the entrance.

Indicator Not Applicable to Steam Turbines—How is the indicated power of a steam turbine determined? C. R.

In steam turbines, the indicator cannot be employed, as the movement of the buckets and the flow of steam are continuous. The mechanical power developed at the shaft is measured by using a friction or Prony brake or electric generators or other loads that are ascertainable.

Adiabatic and Isothermal Compression—What is the difference between adiabatic and isothermal compression of air? G. E. L.

When air is compressed adiabatically, all the heat resulting from compression is retained in the air that is compressed. When compression is performed isothermally, the heat is removed as rapidly as produced, by means of some form of refrigeration.

Pitting of Boilers—In what parts of a boiler does the most pitting occur? D. R.

In most boilers, pitting occurs more rapidly in the shell and other parts that are at the prevailing water line, and probably for the reason that the material at the water line becomes oxidized from contact with air and gas bubbles that are liberated from the water and gathered at the surface.

Jack Shaft and Head Shaft—What is the difference between a jack shaft and a head shaft? W. G.

A jack shaft is a countershaft on which power from a main source is received and transmitted by means of pulleys or gearing to one or more other shafts. In a lineshaft, that length of shafting on which the main or driving power is received is called the "head shaft" and sometimes is designated "receiving shaft" or "first shaft."

Allowable Strength of Welded Joint—What strength is allowable for a welded longitudinal joint of a boiler? J. M. L.

According to the A. S. M. E. Boiler Code, "the ultimate tensile strength of a longitudinal joint which has been properly welded by the forging process shall be taken as 28,500 lb. per sq.in., with steel plates having a range in tensile strength of 47,000 to 55,000 lb. per sq.in."

Relative Value of Round and Square Smoke Flues—What is the relative efficiency of round, square- and rectangular-sectioned smoke flues? R. J. H.

For a given cross-sectional area, the draft-retarding effect is proportionate to the perimeter of the cross-section and therefore is about 12 per cent. greater for a square section than for a circular section and is still greater for a rectangular section. For practical purposes a circular flue may be considered as equivalent to a square one in which one side of the square is equal to 95 per cent. of the diameter of the round flue.

Percentage of Fuel Energy Utilized—What percentage of energy contained in the fuel is utilized in a steam plant having a boiler that evaporates 8 lb. of water per pound of fuel and an engine that consumes 25 lb. of steam per i.hp. per hour if the fuel contains 10,000 B.t.u. per pound? G. N.

With the stated evaporation, the fuel per i.hp. would be $25 \div 8 = 3.125$ lb. per hour, containing 31,250 B.t.u. A horsepower is the development of 33,000 ft.-lb. of work per minute or 1,980,000 ft.-lb. per hour, and as 1 B.t.u. is equivalent to 778 ft.-lb., the heat utilized per hour in the development of a horsepower would be $1{,}980{,}000 \div 778 = 2{,}544.9$ B.t.u. Hence, of the energy contained in the coal, $\frac{2{,}544.9}{31{,}250}$, or 8.1 per cent., was utilized.

Reducing the Size of Pump Suction—Under what conditions may the suction pipe of a pump be made smaller than the inlet provided by the maker? D. U.

For a stated rate of pumpage, a reduced size of suction increases the loss of suction pressure required for overcoming the suction-pipe friction and as much additional power will be required as though the head pumped against were increased by the same amount as the decrease of suction pressure. The conditions under which it would be advisable to reduce the size of the suction may exist, however, where the saving in cost of piping overbalances the increased cost of operation and the reduction of suction pressure is not enough to hinder the desired pumpage output.

Reduction to Equivalent Evaporation f. and a. 212 deg. F.—How is the equivalent evaporation from and at 212 deg. F. computed from the standard evaporation of 30 lb. of water per hour from a feed-water temperature of 100 deg. F. into steam at 70 lb. gage pressure? R. G.

By reference to the steam tables it may be seen that a pound of dry saturated steam at a gage pressure of 70 lb. per sq.in., or 85 lb. absolute, contains 1,183.4 B.t.u. above 32 deg. F. As a pound of feed water at 100 deg. F. contains 67.97 B.t.u., or practically $(100 - 32) = 68$ B.t.u. above 32 deg. F., the evaporation of 30 lb. of feed water per hour from a temperature of 100 deg. F. into steam at 70 lb. gage pressure would require $(1{,}183.4 - 68) \times 30 = 33{,}462$ B.t.u. The latent heat of evaporation, or heat required to evaporate one pound of water from and at 212 deg., is 970.4 B.t.u., and therefore the heat required for the standard evaporation, or 33,462 B.t.u., is equivalent to the evaporation of $33{,}462 \div 970.4 = 34.48$ lb., or as commonly accepted, 34.5 lb. of water evaporated per hour from and at 212 deg. F.

Allowable Working Pressure for Stayed Flat Surface—What pressure can be safely sustained by a flat furnace sheet $\frac{7}{16}$ in. thick stayed by screwed and riveted stay-bolts pitched 8x8 in.? W. F.

According to the A. S. M. E. Boiler Code, the maximum allowable working pressure for stayed flat surfaces with braces or stay-bolts of uniform diameter symmetrically spaced shall be calculated by the formula,

$$P = C \times \frac{t^2}{p^2}$$

where

P = Maximum allowable working pressure, lb. per sq.in.;
t = Thickness of plate in sixteenths of an inch;
p = Maximum pitch;
C = 112 for stays screwed through plates not over $\frac{7}{16}$ in. thick with ends riveted over.

Substituting in the formula, the maximum allowable pressure for the conditions stated is found to be

$$P = 112 \times \frac{7 \times 7}{8 \times 8} = 85.75 \text{ lb. per sq.in.}$$

Equalization of Cutoff in Meyer Valve Gear—Can a Meyer adjustable cutoff valve gear be arranged to secure equalization of cutoff in opposite ends of the cylinder for all adjustments of the valve gear? R. G.

On account of the irregular motion of the piston, due to the angularity of the connecting-rod, equalization for any point of cutoff would require a difference of valve lap for each end of the cylinder and the required difference is variable for different cutoffs. In the Meyer valve gear, the cutoff valve is made in two parts that are carried on a common valve spindle having a right- and left-hand screw and the relative positions of the cutoff edges are varied by rotating the valve stem. Therefore exact equalization for all cutoffs cannot be obtained, but by having different pitches for the screw threads on the valve spindle, equalization can be obtained for two points of cutoff. With the usual proportions of valve gear, a difference of pitches of the right- and left-hand screws that will equalize the cutoff for about $\frac{1}{4}$ and $\frac{1}{2}$ stroke will give practically the same cutoff in both ends of the cylinder for intermediate adjustments of the cutoff.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.— Editor.]

Pumping Machinery Test Duty vs. Operating Results*

By J. N. Chester

SYNOPSIS—The author shows that there are usually wide discrepancies between guaranteed efficiencies and results obtained in practice and points out causes and remedies.

This paper is the result of an effort prompted by a request from our secretary starting with the statement that "we now install pumping engines of 200,000,000 ft.-lb. guaranteed duty, but get much less everyday efficiency," and ending with the admonition that we "dwell on what the coal piles should give us in water pumped."

History relates that over 2,000 years ago, one Alexander the Great wept because there were no more worlds to conquer. This being the case, we are quite sure that "Alec," up to that time at least, had never looked into the possibilities of steam-plant efficiency.

From physics we learn that heat and energy, or work, are equivalent and mutually convertible one to the other. Our pump-station results represent work. The source of the heat to perform this work is coal, and the means for converting the heat of the coal into work is our steam-plant equipment. The percentage of the heat contained in the coal that may be realized in useful work or energy is represented by the water delivered into our mains, and why the losses is the problem before us.

The coal we buy contains, we will say, 100 per cent. of heat. Not that coals do not differ in heat-producing or thermal values, but let us assume that the coal we have contains heat represented by 100 per cent. Then to those familiar with the subject it is well known that with the contrivances in use to this date we have been able to make apparent in work done as represented by the water column delivered with the most efficient machines less than 20 per cent. of the 100 per cent. of heat in the coal fired under our boilers, and in many instances the net result does not exceed 5 per cent. Why this loss?

In the boilers, owing to the heat that must necessarily pass out through the stack so that the temperatures of the hot gases in the boilers may be in excess of the temperature of the steam generated and thus be effective throughout their entire travel through the boiler, coupled with the radiation of the exterior parts of the boiler and the incomplete combustion of fuel represented by the combustible matter remaining in the ash, test boiler efficiencies are not obtained greatly in excess of 70 per cent. Otherwise stated, we realize in net heat delivered as dry steam from the boiler, only 70 per cent. of the total heat contained in the coal, which we termed 100 per cent.

LOSSES IN THE STEAM LINES

Next come the steam lines, and be they long or short, properly or poorly proportioned, bare or well-covered, some radiation must take place and some loss due to friction must be further incurred, for friction represents energy and energy is heat; so, under the best of conditions, we can expect to deliver less than 70 per cent. of heat of the coal converted into steam and less than 70 per cent. at the engine throttle.

Then, owing to the ineffective utilization of the heat delivered at the throttle by the highest-grade steam motors or engines in use today, which seldom exceeds 20 per cent., we find the net results left of our original 100 per cent. in the coal approximately 15 per cent.

As a concrete illustration of the foregoing, recent final and preliminary duty and efficiency tests at Erie, Penn., showed that of the available heat units determined by analysis of the coal fired, the boilers delivered at their outlet nozzles 71 per cent., and of the available heat units received by the steam pipe at the discharge nozzle of the boilers it delivered to the throttle at the engine 99.6 per cent.; and that the engine converted into useful work but 21.5 per cent. of the available heat units delivered at its throttle by the steam pipe, or that the entire combination, not considering auxiliaries of any sort, showed an over-all efficiency of 15.25 per cent.; and still the engine on preliminary test (final test not yet run) performed a duty of 205,348,000 ft.-lb. for each 1,000 lb. of steam.

*A paper presented at the Thirty-sixth annual convention of the American Water-Works Association, New York City, June 5-9, 1916.

But probably, to be more readily understood by the water-works operator, we would better restate this problem in the terms of the relations between test duties based on 1,000 lb. of dry steam and obtained on tests for acceptance as compared with everyday operating results per 100 lb. of coal fired under the boilers.

Before getting too deeply in either discussion, let it be known that we have accorded the field of plants consuming one million and less to the internal-combustion engine and electric-motor driven pump.

For pumping units on which the demand is 1,000,000 gal. or more daily, practical test duties vary from 50,000,000 to 200,000,000 ft.-lb. of useful work performed for each 1,000 lb. of dry steam delivered to such unit. For the same machines the station duty would be expected to vary from 20,000,000 to 125,000,000 ft.-lb. of work done for each 100 lb. of coal fired under the boilers. Why the difference between the maximum steam duty of 200,000,000 and the coal duty of 125,000,000? Also the minimum steam duty of 50,000,000 and the minimum coal duty of 20,000,000?

Pump-station results, as most of us know, are affected by the following: (1) Quality of coal; (2) efficiency of boilers; (3) efficiency of steam lines; (4) station capacity; (5) head against which water is delivered; (6) load factor; (7) adaptability of machinery; (8) compactness of station; (9) low vacuum in condensing units; (10) care in operation and many other minor elements.

For easy handling, let us take a station in which the major unit is capable, when in service, of pumping all the water demanded and whose test duty was 100,000,000 ft.-lb. per 1,000 lb. of dry steam delivered to it, and endeavor to make clear the differences between steam and coal duty.

Naturally, if each pound of coal fired under the boiler would evaporate ten pounds of water into steam at the pressure desired and none of this steam became condensed in the channels conveying it to the engine, then there would be no difference between coal duty and steam duty. Unfortunately this is not true.

AVERAGE PERFORMANCE IN WATER-WORKS

In the average water-works station with the best coal, Pennsylvania or West Virginia product, we are able to obtain an average of only about 8 lb. of water evaporated per pound of coal burned. Consequently, if nothing more than this existed, our steam duty of 100,000,000 would be reduced to 80,000,000 in station duty. Besides, we cannot all locate our stations within a practical shipping distance from the Pennsylvania or West Virginia coal fields, and those who obtain their coal from the Ohio districts must expect about 7 lb. of water per pound of coal, and from the Illinois and Indiana districts, in the neighborhood of 6 lb., so that the latter has reduced the 100,000,000 duty to 60,000,000 duty without further inroads. So much for the quality of coal.

The evaporative results given are based on the ordinary boiler efficiency of about 65 per cent., which calls for intelligent firing, the boiler operating within at least 80 per cent. of its rated capacity, grates that will prevent there remaining in the ash more than 5 per cent. combustible, a stack draft that will supply the coal being consumed with the necessary amount of air, boiler walls sufficiently tight to prevent the admission of air above and beyond the grates in quantities that will interfere with the best combustion, and the whole exterior of such a construction as to provide an insulation that will minimize the loss of heat by radiation.

Unfortunately the above are seldom found in the ordinary small water-works plant in a combination that provides a boiler efficiency greatly in excess of 50 per cent., and efficiencies running as low as 40 per cent. are frequently found; so in the latter case, even when firing a coal from which a high evaporation might be expected, a much lower net result is obtained.

Much more may depend upon whether the steam lines are well proportioned, for if too large and the velocity sluggish, the condensation will be increased. If too small, part of the heat must be lost in friction. If bare, a large amount of useful energy escapes through radiation, and in 90 per cent. of our steam plants the covering has been done to no specifications other than the will of the company manufacturing and installing such commodities, wherein the covering generally stops short of flanges or fittings about two inches on each side, seldom fits the pipe tight, and in consequence is but 50

per cent. as efficient as though it were continuous over fittings and provided against air circulating between the covering and the steam pipe. A 10-per cent. loss of energy between boilers and engines is not uncommon, when by proper care in design and construction it can be kept within 1 per cent.

The next great loss comes from a source that has been frequently referred to in the meetings of this association, and while many of the pump and boiler builders think it is a hobby, yet you may be assured it exists in 90 per cent. of our plants in stern reality. It is the varying demand and head and consequent load factor of the plant, and it is not a matter that either the designing engineer or the operating officials can correct. Metering intensifies it, so even when brought to the minimum it still remains a large factor, causing inroads on economy; for though the water may be pumped once and then to a reservoir, a well-selected engine should, at the time it is purchased, exceed in capacity the demands to be made upon it, and although the reservoir may permit it to deliver at its rated capacity while in operation and thus the maximum of economy from this standpoint obtained, it must, a part of its time, be either shut down or operated below rated capacity, and so subject its economical possibilities to the inroads of the fixed thermal charges that continue whether the pump is in operation at full or half speed.

With 75 per cent. of our water-works plants there exists no high-level reservoir, and consequently the delivery of the pump is governed by the demand on the mains, which varies throughout the twenty-four hours in the ratio of its extremes of about one to three.

Then again, in many plants having a capacity of less than 10,000,000 gal. daily, fire service is rendered by direct pressure, which calls for an increase when the alarm comes in of from 20 to sometimes 100 per cent., for all of which the boiler power must be kept in constant readiness, thus increasing grossly the fixed thermal losses necessarily to be charged against the station's efficiency.

STANDARDS OF ACCEPTANCE TESTS

When an engine is tested for acceptance and to prove the builder's guarantee of efficiency, we unfortunately too often set up in the purchaser's mind a standard which he hopes to, but never in the future does, realize, not only for the reasons already discussed, but for others to follow, one of which is that during this duty test we simply measure the steam used by the engine, neglecting, of course, that used by many of the auxiliaries such as the feed pump, the electric-light engine now to be found in a majority of stations, sometimes the blowing engine that produces the draft, and frequently the air compressor that charges the chambers, the heating of the station and frequently adjacent buildings—all of which may represent a draft on the boilers from 10 to 100 per cent. of that of the main engine.

As an example of the foregoing, extracts from an analysis made by a university professor and his class of a pumping plant in Pennsylvania where one pump in operation did all the work and was ordinarily run at full capacity, the following distribution of steam generated was ascertained:

	Per Cent.
Consumed by main engine	60.45
Consumed by air pump	16.20
Consumed by lighting unit	4.20
Consumed by Holley vent to atmosphere	6.62
Consumed by drains, heating coils, etc.	5.47
Consumed by Holley return and engine jackets	7.06
Total	100.00

The boilers were fed from the pressure in the discharge mains.

The writer, some years ago, during an engine test at Jamestown, New York, measured the water into the boilers and from the discharge of the air pump of the main engine which, aside from the feed pump in the boiler room and a steam jet employed to eject the condensate from the dry well, was the only steam-consuming element in operation other than that steam was being supplied to the jackets of two idle engines to keep the station warm (the temperature outside being 16 below zero), and the final results showed that the water discharged from the air pump and jackets from the main engine was but a trifle over 50 per cent. of the total fed to the boilers during the period of the test.

In recent years, because of our constantly increasing population and consequently congested districts with modern sanitary methods, most of our water supplies, to be safe, must be filtered, and the installation of purification plants unfortunately generally necessitates the water being pumped from the source to the filters and repumped to the mains whence the consumption is drawn. Notwithstanding this, that individual to whom the man immediately responsible for the economy of this station must report forgets this fact and is prone to demand, as a station duty, the test duty of only what may be termed the high-service unit, ignoring all of the elements enumerated and which must necessarily make inroads on the station's efficiency.

There is too great a tendency on the part of the station or operating engineer to neglect or disregard his means for removing the back pressure from the exhaust side of the low-pressure piston in his engines, otherwise known as his condenser and air pump or vacuum-producing facilities; for with even reciprocating engines, nothing less than 26 in., as indicated by the mercury column, should be tolerated, while unexpected visits generally find in the neighborhood of 20 in.

The loss due to low vacuum may be roughly reckoned in reciprocating engines at 1 per cent. for each inch of mercury. Steam turbines require, for economical operation, a much greater vacuum than 26, and while the condensing facilities may be nursed at the time of the test to produce the desired results, the greater is the fall when the lower vacuum of everyday results becomes effective.

Taking up the last of the major elements that tend to reduce plant efficiency, we come to what is too frequently found: The inadaptability of many of the steam-producing, pumping and auxiliary units, due many times, to be sure, to changes that have taken place that are beyond the control of those responsible for their presence, but often to the exercise of bad judgment or none at all in their original selection and installation, arising mainly from an unwillingness to incur the expense of expert advice in the selection and a proneness to permit manufacturers to make the final recommendation.

This reference to manufacturers must not be construed by them as too great a reflection upon their ability to act in such capacity, but from the writer's own experience, which recurs nearly every time a new station is to be built or an old one to be rebuilt, when, first, the individual with electric current to sell appears, and many times accompanied by another with an electrically driven pump to dispose of, and endeavors to convince him that electrically driven pumping machinery, regardless of conditions of service, is the only kind that will properly meet the situation; then comes the steam-turbine driven centrifugal advocate, followed naturally by the builders of the several different types of reciprocating machinery, all of whom thoroughly believe and earnestly insist that what they have to offer is what the conditions at hand demand and only a simpering idiot would select anything else; and so the individual whose experience is limited to the operation of but one plant too frequently falls a victim to the wiles of the overzealous and inconsistent salesman.

[In representation of general conclusions the author presented a number of diagrams showing what results may be expected under different operating condition.——Editor.]

Tests of High-Temperature Furnace Cement*

By W. S. Quigley

The average person, and some who should know better, have exaggerated ideas of the temperatures attained in their furnace, and to which their bricks are subjected, especially when not checked by pyrometers.

I have in my files of catalogs of refractories many statements made by manufacturers that their brick will withstand temperatures from 4,000 deg. F. up. Being modest, few claim over 7,000 deg. or 8,000 deg. I am glad to say that the average manufacturer is becoming more and more conservative in his statements.

The best results obtained by the Bureau of Standards in determining the melting points of 56 samples tested of the best brands of fire-clay brick showed but one that withstood a temperature of 3,135 deg. F. before it melted. The average was considerably under 3,000 deg. F.

I am not taking up the use of this high-temperature cement with chrome, magnesite or silica bricks just now, as I am not prepared to say conclusively what it will do on those bricks, although it is of a nature which should work well on silica or chrome bricks.

I do not mean to convey that ability to withstand high temperature is the only characteristic to be considered. Bricks should be selected for the special duty required, and should be laid in a material which will unite them, making a bond of equal strength of the brick, having the same coefficient of expansion and contraction and capable of withstanding equal temperature without deterioration.

Did you ever consider that a mixture of fire-clay and water having no binding strength is not the proper material to use in laying firebricks?

*Paper read before the Philadelphia Foundrymen's Association.

Firebricks of a quality best suited to meet the furnace conditions are generally selected without any careful consideration of the permanent adhesive value of the material to be used in the joints.

The maintenance of furnace linings is a large item in the cost of production; not only the cost of repairs or renewals must be considered, but the decreased production owing to the time lost.

Usually the falling of an arch, the bulging of a wall or excessive cutting away of a portion of the interior of a furnace can be attributed to a defect in the joints. The fire-clay disintegrates or falls out, allowing the heat to work in between and attack the lining and shorten its life. Very often an arch is lost owing to the clay becoming loosened around one of the roof brick and its falling weakening the whole structure.

Fire-clay does not support the brick; it works loose from expansion and contraction and permits small particles to work in between, gradually widening the spaces until the openings are large enough to admit the circulation of the gases and resultant ruin of the structure.

This furnace cement forms a lasting union, as I will demonstrate this evening, between the materials to be joined, sets at normal temperatures—that is, air sets—and retains its strength regardless of the heat to which it is subjected. The cement is of the same nature as the best qualities of fire-clay brick or tile; in fact, what is more important, it makes it as good all the way from the inside of the furnace where it is exposed to the high heat clear through to the outside of the wall, which may never become much hotter than the surrounding atmosphere.

Tests have proved that this material[1] used as a binder (in place of fire-clay) when air set forms a joint as strong as the material united, and that the strength is not impaired but increased by the action of heat. This property makes a wall or structure impossible to obtain with fire-clay, which must be fused before a bond is accomplished, and as the action of the high temperature does not penetrate to any considerable depth, the effect is only a surface bond, as those know who have had experience in dismantling a furnace.

TESTS OF THE CEMENT

The first test will be the application of the cement to unite some pieces of first-quality fire-clay brick, which you will see is accomplished by buttering a small quantity of the high-temperature cement on the test pieces, which are dry, and after squeezing the pieces together to remove all of the surplus cement and insure a close joint, I will place the two specimens thus formed directly into the small furnace, which is now heated to 1,800 deg. F. This is a severe test and will show that there is no expansion or spreading caused by the cement, and that the latter does not boil out from between the pieces and leave voids or air spaces.

I will likewise make up two specimens, using pieces of high-quality brick and allowing them to partly dry before placing them in the furnace, so that you can compare them with the first two, which were placed directly into the hot furnace while wet.

Now that the two former sample brick first cemented have reached the temperature of the furnace, which is 1,900 deg. F., I will remove them, placing one into the high-temperature furnace, which has not reached 2,800 deg. F., and leave it in there about ten minutes to reach a softening temperature, which will be about 2,800 deg. to 2,900 deg.

While waiting for it to reach that temperature, I will make up two more test pieces, one by putting two pieces of Jersey-clay firebrick together with a Jersey-clay and a Pennsylvania-clay firebrick with Pennsylvania clay, both the clay and brick being from the same works in each instance, and after they are dried and heated to 2,000 deg. F. you will observe that they will fall apart upon the slightest handling. This you all know from experience, but I am doing it here before you to complete the line of experiments.

Now the first sample of Pennsylvania firebrick, which I have just removed from the high-temperature furnace, is so soft that the tongs have made a deep impression in it and the cement joint can hardly be distinguished from the rest of the sample, and what is most interesting, there is no apparent fluxing action caused by the fusion of the cement, as in some of the other samples of so-called high-temperature cements.

Observe that the other test piece, placed in the furnace wet and subjected to 2,000 deg. F. only, is equally as strong at the joint as the similarly prepared one subjected to the higher temperatures and that the joint also has an appearance similar to that of the pieces united.

What I want to impress upon you is not so much that this cement will withstand an abnormally high temperature, as that it will form a permanent bond between the pieces united and continue to do so from normal temperatures to as high a temperature as the refractory material united with it will withstand, and without injuring the brick or acting as a flux at any temperatures that the brick itself withstands.

The second set of samples, or test pieces, of brick were placed in the low-temperature furnace after being dried on top of the furnace and then brought up to 2,000 deg. F., after which one was brought up to a softening temperature.

In my last test I will bring pieces of a Jersey-clay brick, which you have just seen cemented together, up to as close to the point of fusion as I can without melting it, so you can observe the strength of the joint under the most severe conditions, as this sample will vitrify at a somewhat lower temperature than the Pennsylvania bricks formerly tested. As the furnace has reached a temperature of about 3,000 deg. F., it will take only a few minutes.

At this point I wish to say that with this high-temperature cement it is not necessary to dip the brick or tile causing excessive moisture in the new structure, as when fire-clay mortar is used, and also necessary with some special firebrick cements now on the market; therefore, very little moisture has to be driven off in firing up, and the firing-up period may be considerably lessened without injury, especially in larger structures.

This material should be buttered thin and tamped or squeezed to a close fit. It is not advisable to subject new brickwork to a too sudden rise of temperature, and as the fire-clay bricks contract under heat (the action under heat being opposite that of silica, magnesite or chrome, which expand) the tie-rods when provided should be tightened as soon as the moisture is driven off.

Now you will notice that the last sample of Jersey clay had reached a high temperature and was commencing to melt; in fact, had become so soft that it adhered to the bottom of the furnace, yet the strain of removing, grasping the upper part, has but slightly opened the cemented joint, which shows how tenacious the cement is under high heat.

All firebrick or tile should be selected true to size and shape, and warped or mutilated ones rejected. One large company does a considerable business by marketing specially selected firebrick and tiles, all of which are trimmed and trued. The cost is high owing to high freight, rehandling and fitting, but the repeat orders prove the economy obtained, regardless of higher first cost.

[1] Hytempite.

Storage of Oil Fuel

A recent committee report of the National Electric Light Association contains extracts from the requirements of the National Board of Fire Underwriters as regards the storage and use of oil fuel. These are in substance as follows:

All oil used for fuel purposes under these rules shall show a flash test of not less than 150 deg. F. (Abel-Pensky flash-point tester). This flash point corresponds closely to 160 deg. F. (Tagliabue open-cup tester), which may be used for rough estimations of the flash point.

In closely built-up districts or within fire limits, tanks to be located underground with their tops not less than 3 ft. below the surface of the ground and below the level of the lowest pipe in the building to be supplied. Tanks may be permitted underneath a building if buried at least 3 ft. below the basement floor, which is to be of concrete not less than 6 in. thick. Tanks shall be set on a firm foundation and surrounded with soft earth or sand, well tamped into place No air space shall be allowed immediately outside of tanks. The tanks may have a test well, provided the test well extends to near the bottom of the tank, and the top end shall be hermetically sealed and locked except when necessarily open. When the tank is located underneath a building, the test well shall extend at least 12 ft. above the source of supply. The limit of storage permitted shall depend upon the location of tanks with respect to the building to be supplied and adjacent buildings, the permissible aggregate capacity if lower than any floor, basement, cellar or pit in any building within the radius specified being as follows:

Capacity	Radius
Unlimited	50 ft.
20,000 gal.	30 ft.
5,000 gal.	20 ft.
1,500 gal.	10 ft.
*500 gal.	Less than 10 ft.

*In this case the tank must be entirely incased in 6 in. of concrete.

When located underneath a building no tank shall exceed a capacity of 9,000 gal., and basement floors must be provided with ample means of support independent of any tank or concrete casing.

Outside of closely built-up districts or outside of fire limits, above-ground storage tanks may be permitted provided

drainage away from burnable property in case of breakage of tanks is arranged for or suitable dikes are built around the tanks.

When above-ground tanks are used, all piping must be arranged so that in case of breakage of piping the oil will not be drained from the tanks. This requirement prohibits the use of gravity feed from storage tanks. Above-ground tanks of less than 1,000 gal. capacity without dikes may be permitted in case suitable housings for the protection of the tanks against injury are provided.

MATERIAL AND CONSTRUCTION OF TANKS

Tanks must be constructed of iron or steel plate of a gage depending upon the capacity as specified in the following:

UNDERGROUND TANKS INSIDE OF SPECIFIED FIRE LIMITS

Or Within 10 Ft. of a Building When Outside Such Limits

Capacity, Gal.	Minimum Thickness of Material
1 to 560	14 U. S. gage
561 to 1,100	12 U. S. gage
1,101 to 4,000	7 U. S. gage
4,001 to 10,500	¼ U. S. gage
10,501 to 20,000	5/16 U. S. gage
20,001 to 30,000	3/8 U. S. gage

UNDERGROUND TANKS OUTSIDE OF SPECIFIED FIRE LIMITS

Provided the Tanks Are 10 Ft. or More from a Building

Capacity, Gal.	Minimum Thickness of Material
1 to 30	18 U. S. gage
31 to 350	16 U. S. gage
351 to 1,100	14 U. S. gage
1,101 to 4,000	7 U. S. gage
4,001 to 10,500	¼ U. S. gage
10,501 to 20,000	5/16 U. S. gage
20,001 to 30,000	3/8 U. S. gage

Tanks of greater capacity than 30,000 gal. must be made of proportionately heavier metal. All joints of tanks must be riveted and soldered, riveted and calked, welded or brazed together, or made by some equally satisfactory process. The shells of tanks must be properly reinforced where connections are made and all connections so far as practicable made through the upper side of tanks above the oil level. Tanks shall be thoroughly coated on the outside with tar, asphaltum or other suitable rust-resisting material.

FILL AND VENT PIPES

Each underground storage tank having a capacity of over 1,000 gal. must be provided with at least a 1-in. vent pipe extending from the top of the tank to a point outside the building, and to terminate at a point at least 12 ft. above the level of the top of the highest tank car or other reservoir from which the storage tank may be filled. The terminal must be provided with a hood or gooseneck protected by a noncorrodible screen and be placed remote from fire escapes and never nearer than 3 ft., measured horizontally and vertically, from any window or other opening. Vent pipes from two or more tanks may be connected to one upright, provided the connection is made at a point at least 1 ft. above the level of the source of supply.

Tanks having a capacity of less than 1,000 gal. may be provided with combined fill and vent pipes so arranged that the fill pipe cannot be opened without opening the vent pipe, these pipes to terminate in a metal box or casting provided with a lock. Fill pipes for tanks which are installed with permanently open vent pipes must be provided with metal covers or boxes, which are to be kept locked except during filling operations. Fill and vent pipes for tanks located under buildings are to be run underneath the concrete floor to the outside of the building.

Suitable filters or strainers for the oil should be installed and preferably be located in the supply line before reaching the pump. Filters must be arranged so as to be readily accessible for cleaning. Feed pumps must be of approved design, secure against leaks and be arranged so that dangerous pressures will not be obtained in any part of the system. It is further recommended that feed pumps be interconnected with pressure air supply to burners to prevent flooding.

Glass gages, the breakage of which would allow the escape of oil, are to be avoided. If their use is necessary, they should have substantial protection or be arranged so that oil will not escape if broken. Pet-cocks must not be used on oil-carrying parts of the system.

Receivers or accumulators, if used, must be designed so as to secure a factor of safety of not less than 6 and must be subjected to a pressure test of not less than twice the working pressure. The capacity of the oil chamber must not exceed 10 gal. A pressure gage must be provided; also an automatic relief valve set to operate at a safe pressure and connected by an overflow pipe to the supply tank, and so arranged that the oil will automatically drain back to the supply tank immediately on closing down the pump.

If standpipes are used, their capacity shall not exceed 10 gal. They must be of substantial construction, equipped with an overflow and so arranged that the oil will automatically drain back to the supply tank on shutting down the pump, leaving not over 1 gal., where necessary, for priming, etc. If vented, the opening should be at the top and may be connected with the outside vent pipe from the storage tank, above the level of the source of supply.

Piping must be run as directly as possible and pitched toward the supply tanks without traps. Overflow and return pipes must be at least one size larger than the supply pipes, and no pipe should be less than ½-in. pipe size. Connection to outside tanks should be laid below the frost line and not placed near nor in the same trench with other piping.

Readily accessible shutoff valves should be provided in the supply line as near to the tank as practicable, and additional shutoffs installed in the main line inside the building and at each oil-consuming device.

Controlling valves in which oil under pressure is in contact with the stem shall be provided with a stuffing-box of liberal size, containing a removable cupped gland designed to compress the packing against the valve stem and arranged so as to facilitate removal. Packing affected by the oil must not be used. The use of approved automatic shutoffs for the oil supply in case of breakage of pipes or excessive leakage in the building is recommended.

Cheaper Gasoline Predicted

Officials of the Standard Oil companies are quoted in the New York "Times" as saying that the worst has passed in the skyrocketing of gasoline prices and that a reduction is to be expected soon. The hope, according to an official who has to do especially with gasoline, is based on two factors: First, that the Standard Oil laboratories have found out how to extract more gasoline from crude oil, and second, that the gasoline-producing quality of much of the oil from the southwestern field is improving.

It was explained that the present high price of gasoline was due to a combination of causes which, it was shown, it was not easy for the layman to comprehend. In the first place, there is the war. Most of the sources of production in Europe are not producing at this time. The Dardanelles being closed, the Allies cannot get gasoline from the Russian fields, and Russia isn't selling it to anyone else. The Russians and Austrians have been battling over the Austrian oil fields, and production is at a standstill there. That makes a large demand upon the American supply.

Again, the German, Austrian and Turkish markets for the byproducts of crude oil other than gasoline are cut off. That makes an over-production of byproducts, the loss of profit on which must be borne in large part by users of gasoline.

Another factor in the great advance which has set the present record price was that, two months or so ago, when the heavy production season was beginning, the production of the Cushing fields in Oklahoma fell off almost 50 per cent. and what oil continued to flow did not produce the same amount of gasoline as before.

A. I. E. E. Annual Meeting

The thirty-third annual convention of the American Institute of Electrical Engineers was held at Cleveland June 27-30, with headquarters at the Hollenden. In the absence of the mayor, Floyd Waite, secretary of the Department of Public Service, welcomed the members. President Carty then delivered the annual presidential address, taking as his subject "The Relation of Pure Science to Industrial Research." He pointed out that industrial-research laboratories are rather the exception in this country and that it is the duty of the institute to impress upon the manufacturers the economies in their processes which might thereby be made possible. Conditions created by the present European War, he believed, would be large factors in aiding industrial research.

C. le Maistre, general secretary of the International Electro-technical Commission, who is visiting this country as a representative of the British societies, then read a paper on the development of engineering standards in Great Britain.

The professional papers of the morning session dealt with industrial power; they were "Electric Drive for Reversing Rolling Mills," by Wilfred Sykes and David Hall; and "Motor Equipment for the Recovery of Petroleum." At the power-transmission session in the afternoon two papers were read, one by V. M. Montsinger on "Effect of Barometric Pressure on Temperature Rise of Self-Cooled Stationary Apparatus," and the other, "Restoring Service After Necessary Interrup-

tion," by F. E. Ricketts. The latter will be abstracted in a later issue.

Wednesday morning's papers, all dealing with protective apparatus, were: "Studies in Lightning Protection on 4,000-Volt Circuits," by D. W. Roper; "Experience in Recent Developments of Central-Station Protective Features," by N. L. Pollard and J. T. Lawson; "Protection of High-Tension Distribution Systems by Isolating Transformers," by O. O. Rider; "Megger and Other Tests on Suspension Insulators," by F. L. Hunt; "Experiences in Testing Porcelain Insulators," by E. F. Creighton; "New Method of Grading Suspension Insulators," by R. H. Marvin. Those of Thursday morning were: "Effect of High Continuous Voltage on Air, Oil and Solid Insulation," by F. W. Peek, Jr.; "The Corona Voltmeter," by J. B. Whitehead and M. W. Pullen; "Theory of Parallel Grounded Wires and Production of High Frequency in Transmission Lines," by E. F. Creighton. Both Wednesday and Thursday afternoons and evenings were given up to sports and entertainment, including an outing and games at Nela Park, an automobile excursion and a theater party for the ladies. A dinner-dance and reception was held on Tuesday evening.

An innovation in Friday's technical program provided for its being held in conjunction with an all-day boat trip on the "City of Erie." At this session the following papers were read and discussed: "Suggestions for Electrical Research in Engineering Colleges," by V. Karapetoff; "Tractive Resistances to a Motor Delivery Wagon on Different Roads and at Different Speeds," by A. E. Kennelly and O. R. Schurig; "Application of a Polar Form of Complex Quantities to the Calculation of A.-C. Phenomena," by N. S. Diamant.

Over 250 members of the institute registered during the convention.

Powdered Coal as Fuel*

By Joseph Harrington†

SYNOPSIS—Relates the objections which have been made to powdered-coal burning and tells of its application to locomotives.

Not only to promote combustion efficiency, but to more perfectly pulverize, the coal should be practically dry, 1 per cent. of moisture being the maximum; ½ of 1 per cent. is ordinarily required. Under these conditions the coal, when pulverized, remains quite fluid and will break down under the influence of the crushing rolls with much less expenditure of power than when damp. In order that the fuel may remain suspended in the carrying air in the furnace chamber during combustion, it is necessary to reduce the coal to a certain degree of fineness. After much experience this standard has been established as follows: 85 per cent. must pass through a 200-mesh screen, and 95 per cent. through a 100-mesh screen.

As to the quality of coal most suitable for pulverization, no arbitrary limits can be established. Broadly speaking, the greater the volatile combustible content the more readily will the coal ignite and burn and the less dependent will be this process upon the size and proportions of the combustion chamber. As the volatile content decreases, however, more dependence must be placed upon the proportions and locations of the surrounding brickwork, to maintain the temperature until ignition is complete. Anthracite has been burned in a pulverized form, but it must be finely ground and must be burned in a rather confined space, so that the ignition may be prompt and aid rendered by nearby brickwork during the period of early combustion.

Several types of machinery that are commercially marketed will satisfactorily pulverize coal. They are divided broadly into air separation machines and screen machines. In the former class there is an upward current of air produced by a fan that has a carrying capacity sufficient to take with it the finest particles, but which will not lift the coarser ones. As soon, therefore, as the coal is reduced to the required degree of fineness, this air current will lift the particles and take them away and will then deposit them in a receiving tank by means of a cyclone separator, which is usually vented in some manner to prevent the loss of dust.

In the screen mill the coal is continually thrown against a screen that permits the fine particles to pass through but causes the coarser particles to fall back under the rolls. Pulverization can be effected in a tube mill or ball mill, with an expenditure of power and cost not greatly different from that of the other types.

The pulverized fuel, being collected in a hopper, is conveyed either by screws or pneumatic means to the burner, which is situated at the furnace to be served. At this particular point there is a difference of opinion and a variety of apparatus is used. It is now generally conceded that the most efficient results are obtained when the coal dust is carried into the furnace in a stream of air the volume of which is just sufficient to supply the oxygen necessary for its complete combustion.

This mixture of coal and air must be made in fairly close proximity to the furnace, the reasons being that when this mixing is done, there is produced an explosive compound which must not be allowed to accumulate. The velocity of the entering jet must be greater than the rate of flame propagation to prevent burning back into the pipe.

Another reason for making the explosive mixture close to the furnace is that there is a tendency for the coal to separate and lose its uniformity of mixture, under which condition it is obvious that part of the jet would be over-supplied with coal and the other part over-supplied with air. Various devices have been provided for producing and maintaining the required uniformity of mixture.

In the existing commercial installations the fuel is removed from the storage hopper by means of a screw of special design which is placed at the bottom of the hopper and is usually driven by some form of variable speed device, thereby securing control over the amount of coal extracted per unit of time. It is well known that the delivery from such a screw is not uniform, the coal being delivered in little masses and producing a distinct pulsation in the furnace. To reduce this effect these screws have been made of double and triple thread, in which case there are two or three discharges per revolution in place of one. This is an improvement, but even under these conditions a noticeable pulsating effect is observed. Devices have been developed for passing this discharged material over a perforated screen or over a moving disk operated at high speed, the idea being to smooth out the inequalities and produce a continuous flow of dust. Some of these devices have proved their ability to secure this effect. Once established, this uniformity must be maintained, and if it is necessary to have the mixer at a considerable distance from the furnace, means must be provided for continual agitation of the air current that the fuel cloud may remain of constant density. This is not a difficult matter, but is one which must not be overlooked.

Like all new things, the early history of powdered coal is full of accounts of failure. This has left on the minds of the engineering public an impression which it will take years of successful application to eradicate. The early experimenters did not understand the necessity of fine grinding, and it would seem that they did not appreciate the influence of furnace design upon the temperature of the resulting gases. The coal was powdered sufficiently fine, however, to develop intense temperatures, even though part of the fuel was lost by falling to the bottom of the furnace and being extracted with the slag and ash.

Insufficient combustion space and the ease with which this fuel can be mixed with the minimum amount of air combined to produce abnormal temperatures and a direct contact of flame and brickwork. The blowpipe effect of the high velocity jet acted to melt out the brickwork upon which it impinged. A layer of melted lava formed by the fusing of both ash and brickwork formed in the bottom of the combustion chamber and naturally discouraged the people who depended upon this fuel for continuous service.

Later, difficulty was encountered by reason of the minute particles of liquid slag being carried in suspension and deposited upon the tube sheet or water tubes of the boiler, thereby closing up the flame space, sometimes putting the boiler out of action. These effects are particularly conspicuous with certain grades of coal, but noticeably absent with other grades of coal. Only recently has the research work been carried to a point where any knowledge has been obtained of what causes this trouble and what coals are most suitable for this work.

From the viewpoint of the theorist powdered coal forms one of the best means ever advocated for the promotion of combustion efficiency and commercial economics. There is in

*From a paper read before the Chicago section of the American Society of Mechanical Engineers.

†Advisory engineer, Chicago.

all transformations of energy unavoidable loss, and there is no apparatus that will gasify coal with 100 per cent. efficiency. In the producer there are many losses that reduce the available heat in the gas, and in the mechanical stoker there are unavoidable losses due to various forms of incomplete combustion. Only in the case of powdered coal is the actual solid fuel both gasified and completely consumed directly within the chamber desired to be heated. With thorough pulverization all the coal is burned in suspension, and in practice but a fraction of 1 per cent. is lost in the flue dust or slag pan.

On account of the fuel being conveyed into the furnace by the air which is afterward to be used in its combustion and on account of the diffusing of the coal throughout the air in cloudlike formation, there is a possibility of a mixture that can be secured by no other means. Each particle of coal is surrounded by air, and on account of the extreme fineness of the particle instantaneous oxidation occurs.

The result is efficient combustion, and it is necessary to deal only with the effects of the high temperature thereby obtained. That it is now possible to control this temperature while not sacrificing any material gain due to it is definitely established. Moreover, the definite control of the amount of air per unit of coal permits of the most perfect variation in the results obtained.

Steam generation by the use of powdered coal as a fuel is still in the experimental stage, and herein, if anywhere, powdered coal will meet severe competition. That steam can be efficiently produced in this way is unquestioned if the mere matter of combustion and evaporation is considered. Whether it can be done more economically than at present done by the best mechanical stokers still remains to be commercially proven, and even with powdered coal, gas analyses better than 16 per cent. of CO_2 are not developed. With the mechanical stoker the CO_2 can be maintained around 14 per cent.

With powdered coal the loss in the ashpit and in the flue does not exceed 1 per cent. and in the best mechanical stokers will not exceed 2 per cent. of the coal fired. A possible advantage in favor of powdered coal of 2 or 3 per cent. in combustion efficiency is offset by the cost of fuel preparation. It is not reasonably to be anticipated that better than 96 per cent. efficiency can be obtained, and this is a figure possible with the mechanical stoker.

It is in cases such as the locomotive that powdered coal shows most favorably. Here there is not only the single problem of combustion efficiency, but a long list of related conditions that are effected thereby. A summary of the advantages incorporated in the report of the standing committee on powdered coal of the American Railway Fuel Association was presented. The committee was of the opinion that the effectiveness and utility of the use of fuel in pulverized form has been demonstrated from the past year's development and that the progress in the use of this method of stoking and burning bituminous and anthracite coals and lignites for generating power, heat and light on railways will be quite marked from now on.

The constantly increasing cost of railway fuel at the mine, the scarcity of fuel oil, the domestic and export demand for the larger sizes of coal, the prohibitive cost for briquetting the smaller sizes of coal and of lignite for railway use, the payment of labor on the run-of-mine basis for mining bituminous coals and the necessity for eliminating smoke, sparks and cinders will all tend toward the inauguration of this practical means and method for increasing the efficiency of steam-boiler operation, which today affords the greatest opportunity for improving locomotive and power-plant costs and performance and for changing public sentiment by smoke abatement.

A phase of the combustion problem, both in connection with powdered coal and mechanical stokers, which is but now receiving adequate attention is the study of the temperatures and conditions under which ash will melt. Engineers have always recognized the fact that certain coals were greater clinker producers than others, and this was laid at the door of the sulphur content. Recent experiments have shown that the sulphur is not the controlling element, although the exact causes are not yet sufficiently well known to be definitely stated.

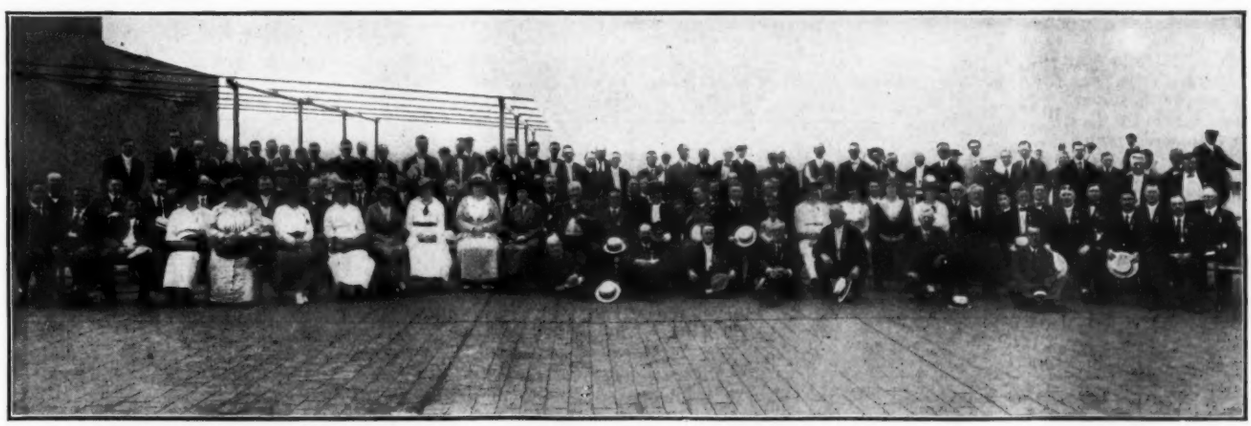
Coal ash will melt at temperatures between 2,300 and 2,700 deg. F. Furnace temperatures in commercial practice run between 1,800 and 2,800 deg., so that it is possible to secure coals the ash from which will pass through the furnace without fusing. Under these conditions no clinker formation is encountered and the coal is rated as satisfactory from this standpoint. In the same furnace another coal will clinker badly and give trouble. There is no hard-and-fast rule, therefore, which can be stated for the selection of a coal.

The temperature obtained in service, which is a function of the rate of combustion, the amount of excess air and the proportions of the furnace chamber, must be determined and analyses of the fuel made to determine whether it will be suitable under the given conditions. Like many other scientific investigations, the value of a few dollars spent in this manner is not always appreciated, and the user will tolerate the formation of clinkers for months before he turns to another source of coal supply. When he does so, he may or may not solve his problem, and it becomes necessary to purchase and consume a variety of coals before one is found which is suitable to his needs.

In powdered-coal work with the more scientific combustion process, the necessity for proper knowledge of the point of ash fusibility is greatly increased. The day is rapidly approaching when the burning of coal will be considered a scientific chemical reaction in which the elements are supplied with exactness and understanding, and the result obtained, corresponding in definiteness to the precision of the mixing process, will be made to conform to the requirements of the service.

Annual Convention A. O. S. E.

The thirtieth annual convention of the American Order of Steam Engineers was held in New York City, June 26-30, with headquarters at the McAlpin Hotel. The sessions of the delegates were held in the banquet hall on the first mezzanine floor of the hotel, and the handsome grillroom was artistically arranged and daintily decorated for the use of the supplymen for their mechanical display. The engineers and supplymen were loud in their praise of Joseph F. Carney, the superintending engineer of the building, for his generous and untiring assistance in making for them the handsomest exhibit hall in the history of the organization and in many other ways adding to the comfort and welfare of the delegates and guests. There were upward of fifty booths displaying the goods of many of the leading firms in the supply trade.



AMERICAN ORDER OF STEAM ENGINEERS ON ROOF OF HILL BUILDING

The attendance of engineers was unusually large, there being 13 officers, 17 past supreme chiefs and 97 delegates.

The opening exercises of the convention took place on Monday evening. The chair was occupied by Past Supreme

Chief George R. Richardson, who accepted the position at short notice, in the absence of William G. LeCompte, who was awaiting marching orders in the Seventh Regiment Armory. The first speaker was J. William Pairent, supreme chief, who told of the necessity for efficiency in the engineer of the present and future and hoped that the visit of the A. O. S. E. to New York City would result in benefit to all. J. B. Heilman, past supreme chief, spoke on the subject of technical journals. He explained the need of feeding the mind as well as the body and called the engineering magazine the department store of the engineers and their very best friend. Charles A. Wilhoft, president of the Supplymen's Association, told of the great advantage of conventions in giving the exhibitors and their representatives the opportunity of meeting their engineer friends in large numbers. At this juncture, "Bill" LeCompte, in regimental uniform, who had secured a special furlough of three hours, was introduced. He gave a brief and interesting history of the formation and advancement of the American Supplymen's Association. Mr. LeCompte was loudly cheered as he left the hall. Between the addresses Mrs. Emilie Antony played selections on the piano. At the close of he entertainment adjournment was made to the grillroom, where the official opening of the exhibition took place.

On Tuesday morning a trip was made in autos to Feltman's, Coney Island, where a shore dinner was enjoyed, after which a visit was made to the many interesting features in Luna Park.

Wednesday noon motor buses conveyed the convention to the building of the Hill Publishing Co., and after partaking of luncheon on the roof, the official photograph was taken. The company then made a complete inspection of the offices, the several operating departments and the engine room.

On Wednesday evening an enjoyable entertainment was given in the banquet hall by the "New York Bunch," Frank Martin acting as master of ceremonies. On Thursday afternoon there was a sight-seeing auto drive through interesting parts of the city; light refreshments were served en route. The trip was complimentary by Jenkins Bros.

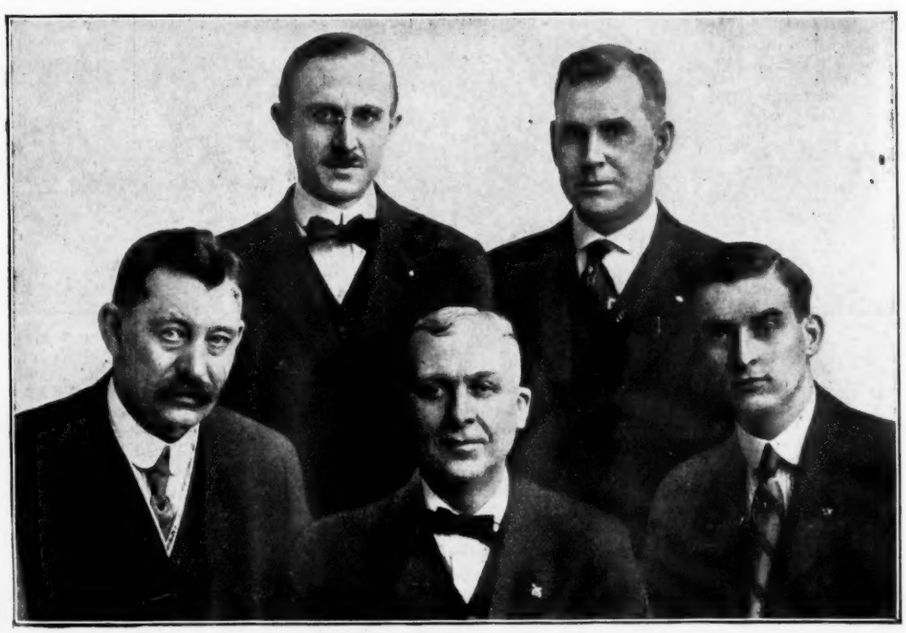
At the closing session of the delegates on Friday morning the following supreme officers were elected and installed: J. William Pairent, supreme chief; John J. McKewen, first assistant engineer; John Martin, recording engineer; F. J. Armbruster, corresponding engineer; William H. Tyson, treasurer engineer; W. R. Smith, senior master mechanic; Charles A. Caldwell, junior master mechanic; J. J. Morris, inside sentinel; Philip A. Kirkwood, outside sentinel. Hiram Trout, chaplain; D. B. Heilman, trustee.

At the final meeting of the American Supplymen's Association the following officers were elected: Hart Hill, Lagonda Manufacturing Co., president; Alfred Smith, Jenkins Bros., vice-president; Porter G. Jones, Dearborn Chemical Co., secretary; John W. Armour, "Power," treasurer; William Lindenfelser, Jr., of the Texas Co., was appointed director of exhibits.

J. William Pairent was the recipient of a box of golden eagles, the gift of the supplymen. Hiram Trout was presented a silver-mounted walking stick by the engineers. The supplymen gave Charles A. Wilhoft, retiring president, a handsome gold watch. The next convention will be held in Philadelphia, in June, 1917.

Convention Committee of the N. A. S. E.

The next national convention of the National Association of Stationary Engineers will be held in Minneapolis, Minn., Sept. 11 to 16. The committee is shown in the group. Standing, left to right: John D'Arcey, chief engineer Northwestern Blau Gas Co., St. Paul; J. A. Johnson, state president. Sitting, left to right: H. T. Mueller, president, N. A. S. E. No. 8, Minneapolis, and chief engineer, Washburn-Crosby Co.; J. M. Williams, chairman; and J. F. Gould, secretary. The West Hotel will be headquarters, and the exhibit will be held in the armory.



N. A. S. E. NATIONAL CONVENTION COMMITTEE

ENGINEERING AFFAIRS

The American Electric Railway Association will hold its annual convention this year at Atlantic City on Oct. 9 to 13. The program is now in preparation.

The Canadian Association of Stationary Engineers will hold its annual convention in Montreal during the week commencing July 24. There will be an elaborate display of power plant equipment by the Supplymen's Association connected with the C. A. S. E. This exhibition will be held in the technical school and will be open to the public day and evening. H. L. Peiler and his committee are widely advertising this convention, and an enjoyable and instructive program of events is expected.

The Ohio Electric Light Association will hold its twenty-second annual convention at Cedar Point, Ohio, July 18-21, 1916. Headquarters and meeting place, Breakers Hotel. Papers of interest to our readers are: "Legislation Needed by Company and Consumer," "Taxation of Public Utilities," "Municipal Ownership; Its Shades and Shadows," reports of Station Operating Committee and Transmission and Distribution Committee, an address on "The Public Policy of a Utility," report of Committee on Standardization of Voltages, in addition to the reports of the regular standing committees.

MISCELLANEOUS NEWS

Mapleton, N. D., has called for bids for an electric-light and power plant.

In Birmingham, Ala., there is at present strong agitation for the construction of a municipal plant.

Anthon, Iowa, recently voted in favor of a $20,000 bond issue for a municipal electric-light and power plant.

Caledonia, Minn., is to be served with electric light and power by a transmission line to be built from Spring Grove by the Root River Light and Power Co.

The Northern Electric Power Co. has purchased a power plant at Eyota, Minn., and will extend transmission lines to several villages in the vicinity of Winona, Minn.

Governor Brumbaugh of Pennsylvania has approved the merger of the Bucks County and Boylestown electric companies into the Pennsylvania-New Jersey Power and Light Co. with a capital of $100,000.

A Disastrous Fire Was Recently Caused by a bolt of lightning striking the station of the Wisconsin-Minnesota Light and Power Co. at La Crosse, Wis. Power and lighting service in the city was completely tied up, and the damage was estimated at $15,000.